Canada. Dept. of Communications.

Telecommunication Studies. 1971

2a-2c.

2(a)

THE CANADIAN TELECOMMUNICATIONS INDUSTRY: STRUCTURE AND REGULATION

Telecommission Study #2(a)

submitted to

Government of Canada Department of Communications

Walter D. Gainer, Ph.D.

University of Alberta

August 1970

Available by mail from Information Canada, Ottawa,
and at the following Information Canada bookshops:

HALIFAX
1735 Barrington Street

MONTREAL
1182 St. Catherine Street West

OTTAWA
171 Slater Street

TORONTO
221 Yonge Street

WINNIPEG
393 Portage Avenue

VANCOUVER
657 Granville Street

or through your bookseller

Price $1.50 Catalogue No. Co41-1/2A

Price subject to change without notice

Information Canada
Ottawa, 1971

PREFACE

This study was commissioned in March of 1970 by the Department of Communications as part of a larger series of Telecommission studies dealing with various features of the telecommunications industry in Canada. In an effort to meet the mid-summer deadline imposed for the completion of all studies, the limited time available for this particular investigation precluded a detailed analysis of cost characteristics. The approach adopted here has concentrated therefore on those aspects of industry structure and operations which are most closely connected with regulatory matters.

The progress of the study has been greatly hastened through the efforts of Professor Max D. Stewart of the Department of Economics, University of Alberta, who assisted with the numerous interviews and in the analysis of information from various submissions, and who acted as research consultant throughout. Senior representatives from the following firms or organizations were interviewed during the months of May and June:

Bell Canada
Manitoba Telephone System
Edmonton meetings with officials of:
Alberta Government Telephones
Bell Canada
British Columbia Telephone Company
Maritime Telegraph and Telephone Company
New Brunswick Telephone Company

CN-CP Telecommunications

Electronics Industries Association of Canada
Canada Wire and Cable Co., Limited

Rogers Cable TV Limited

A.G.T. Data Systems Limited
Computel Systems Limited
L & W Data Systems Limited
Multiple Access General Computer Corporation

Stapleton, Dowdeswell, Kelly and Hunt, Ltd.
(systems engineering)

Clarkson, Gordon and Company
(data processing consultant)

Interviews arranged by Canadian Government officials abroad provided useful background information in the early stages of this study concerning:

Hong Kong Government Authority on Telecommunications Systems
Hong Kong Telephone Co. Ltd.
(shareholder)
Cable and Wireless Ltd.
(U.K. Government)

Singapore Telephone
(Singapore Government Telecommunication Department)

Nippon Telegraph and Telephone Public Corporation
(Japanese Government; full range of telecommunications services)

Walter D. Gainer, Ph.D.
University of Alberta
August 1970

CONTENTS

CHAPTER 1

OUTPUT AND MARKET CHARACTERISTICS OF THE CANADIAN TELECOMMUNICATIONS INDUSTRY

1.1. The telecommunications industry concerns the electrical or electronic sending and receiving of messages by parties at different locations. The type of messages which people wish to send and the mode of their transmission are an interactive system. For example, the rapidly increasing use of the services of data processing firms means greater demand for higher speed and more flexible communications facilities. Although, for some purposes, it might be convenient to consider only the commercial communications carriers as a separate industry in isolation, it is much more fruitful to examine their interconnections with other phases of message sending, which are also essential elements in any communication network. One must be aware that the clear distinction in rates between local and long distance telephone calls has no special operational validity for the individuals and companies who wish to communicate with one another. Some calls across twenty miles are now "long distance" and others in major metropolitan areas are now "local" --a distinction that is obviously subject to change over time. It is a crucial matter for policy questions to see the interfaces between public carriers and other groups in society because those interfaces are the fields of combat, the points of conflict. The effective functioning of Canadian communications, which are at least as important as transportation facilities, rests in large part upon the establishment of interconnecting arrangements that aid, and do not impair, technical advance.

1.2. Modern society and business send and receive three basic kinds of message--voice, picture, data. A particular user of a communications network will often desire to send or receive more than one type of message. From the user's point of view, acceptable solutions to whatever communications problems may present themselves encompass to a greater or lesser degree all segments of the routing of a message right from and to the instrument or device on an office desk or kitchen wall. So long as the overall result suits the needs of the user, he shows little concern regarding the intercorporate relationships that carry the message on its way. If inadequacies become apparent, he is likely to become interested in knowing that corporate arrangements have not inhibited the adoption of any useful organizational or technical arrangements that would remove the inadequacies.

Commercial Common Carriers, Telecommunications

1.3. In Canada two organizations, The Trans-Canada Telephone System and CN-CP Telecommunications, provide the major nationwide networks for telephone, telegraph, radio, television and data transmission and specialized services for defence purposes. A Crown corporation, Canadian Overseas Telecommunications Corporation, affords overseas communications links with Canadian users by cable, radio-telephone, radio-telegraph and satellite, subject to the provisions of the International Telecommunication Convention. It operates a satellite ground station at Mill Village, Nova Scotia.

1.4. The eight member companies of the Trans-Canada Telephone System

(TCTS) account for more than 90 per cent of the telephones in Canada. From east to west, there are four shareholder "Bell" companies, three provincially owned organizations in the prairie provinces, and the British Columbia Telephone Company, which is controlled by the largest independent United States telephone company, General Telephone and Electronics Corporation. Bell Canada and British Columbia Telephone each own telephone companies that are not themselves members of TCTS; these two principal sets of privately owned companies have about 81 per cent of the telephones in use in Canada. The three provincially owned systems account for approximately 13 per cent of the country's telephones; the municipally owned systems of Edmonton and Thunder Bay operate slightly less than three per cent of the nation's telephones; and the remaining hundreds of smaller independent private companies have slightly more than three per cent. As might be expected, the telephone common carrier system is one of high concentration of ownership.

1.5. The telephone system is not subject to uniform regulation. The Canadian Transport Commission has jurisdiction over its two largest members--Bell Canada and British Columbia Telephone. The three member companies in the Atlantic provinces are shareholder owned and come under provincial regulatory jurisdiction, as do the government owned Manitoba and Alberta systems. Saskatchewan Telecommunications is self-regulated through cabinet-appointed directors, the Minister of Telephones and a legislative standing committee. The agreed schedule of rates of the Trans-Canada Telephone System has not been determined in the main by the influence of carefully considered regulatory policies of the various federal and provincial authorities.

1.6. The Canadian telephone network uses open wire, cable, coaxial cable, and microwave. In the near future the joint public-private consortium, Telesat, will operate a communications satellite. The speed of technological advance in communications makes hazardous an estimate of how remote the introduction of further new techniques will prove to be. It does seem evident that there is great promise of dramatic increases in system capacity through the use of wave guides and, ultimately, laser tubes. There are a good many technical and economic challenges in the telecommunications field alone.

1.7. CN-CP Telecommunications, under federal jurisdiction, is a joint undertaking of the country's principal railways--Canadian National, a Crown corporation, and Canadian Pacific, a shareholder company. It provides nationwide telegraph services and an extensive microwave network capable of handling voice, picture and data transmission. The routing of a telegraph message is likely to include an originating telephone connection and another one at the final destination. There are also a good many cases where the most appropriate message route for computer services companies and for their customers will include one or more telephone segments. Unlike CN-CP telegraph services, CN-CP microwave facilities are provided chiefly on a private, leased circuit basis. The voice and data transmission business of CN-CP Telecommunications has been recently experiencing more rapid expansion than its slow-growth telegraph operations. Its greater promise means more active concern and interest on the part of CN-CP Telecommunications in promoting that part of their business.

Corporate Integration

1.8. The two major privately owned telephone corporate systems possess strong elements of vertical integration between the provision of communications services and the manufacture of many essential components of a communications network--telecommunications equipment, wire and cable, and a variety of peripheral equipment. Bell Canada controls or has a substantial interest in three companies that are members of the Trans-Canada Telephone System--The New Brunswick Telephone Company Limited, Maritime Telegraph and Telephone Company Limited and Newfoundland Telephone Company Limited--and several other telephone companies. Bell Canada owns the largest telecommunications manufacturer, Northern Electric Company Limited, which has a subsidiary, Microsystems International, which means a highly significant element of backward vertical integration. The vertical integration that involves British Columbia Telephone Company results from its United States parent, General Telephone and Electronics Corporation, owning two major telecommunications manufacturing companies that operate plants in Canada--Automatic Electric and Lenkurt. Several major telephone companies have already made tentative moves indicating interest in greater ownership and direct control of physical facilities in present or projected cable TV systems. CN-CP Telecommunications has integrated forward into the computer services industry through the acquisition by Canadian National and Canadian Pacific of 25.5 per cent each of the stock of Calgary-based Computer Sciences Canada Ltd. from its former U.S. parent, Computer Sciences Corporation.

1.9. The effect of the integrated corporate systems is fourfold. First,

that highly significant part of the market is largely foreclosed to independent manufacturers. Secondly, their manufacturing components afford the opportunity for rivalry with the independents that could fail to meet the test of open competition. How often and to what extent the carrier-affiliated organizations have seized their special opportunities may prove to be largely undetectable. A part of their special market position is derived from and depends upon the monopoly position of the associated carrier and it tends to increase concentration and to narrow choice. Thirdly, carrier entry into cable television represents a private corporate decision to extend its monopoly position into a new field with little or no open discussion and resolution of the relevant public interest issues. Although careful scrutiny of that problem by the appropriate regulatory authorities might lead them to decide in favour of the action taken by the company, that possible agreement is insufficient defence for the continuation of a procedure that cannot always be relied upon to safeguard the public interest. Fourthly, the forward integration by CN-CP into the computer services industry poses an even more serious problem of extending monopoly power. The computer services industry must have equal and reasonable access to wholly satisfactory communications. Assurance of that necessary requirement being met is significantly weakened by one of two carriers being allowed to become a computer services rival. The assurance would likely be lost if both carriers were allowed to enter that field.

1.10. Each of the two cross-country systems, TCTS and CN-CP, provides a variety of special services such as distance dial teletypewriter connections between subscribers of one or other of the systems, TWX and

Telex (no interconnection between them), a variety of channel widths for specific transmission purposes, and mobile radio-telephone connections. The basis of charges and the rates themselves have usually been established by negotiation and in some instances by unilateral action by a carrier. They have not been subject to direct regulation. In view of the limited choice open to users and of the quite poor substitutability of other communication means, there is a *prima facie* presumption that these rates more often than not tend toward value-of-service limits rather than being cost-related. It would therefore be unsound regulatory practice to accept the existing rates as valid criteria at such time as more comprehensive regulation of these rates takes place. A rigorous examination might uphold some charges and strike down others.

Related and Separate Industries

1.11. The Canadian computer services industry has experienced remarkable growth in recent years and has shown considerable capability of an innovative kind. The expertise of data processing firms in writing and adapting useful programmes contributes significantly to the opportunity for Canadian industry to make use of computer capacity in striving to become more efficient. Low-cost and technically suitable communications links are necessary in order to have the many individual customers of computer services companies realize the economic advantages of large-scale computer installations. The relatively large number of firms and the considerable variety of services offered strongly recommend their continuance as an unregulated industry. Except for batch processing

of data physically delivered to a computer centre, the major services --remote batch processing, real-time use, interactive time sharing with remote terminal connections, canned and contract programming, and systems management--all require highly adaptive, divisible and economical communication connections.

1.12. Cable television is a high growth industry in Canada. The Canadian Radio-Television Commission is the regulatory agency. It selects from applicants which parties are granted an exclusive licence to operate a cable television distribution network throughout a clearly defined territory, often part of a large city or metropolitan area. Since an assigned territory is exclusive to a single firm, each cable television company has a clear monopoly grant from public authorities, subject to the conditions imposed by the Canadian Radio-Television Commission. Once a preliminary stage of market development has been passed, the circumstances of a cable television operation are those of a classic monopoly and thus seem to call for regulation of rates and overall rate of return, as well as standards of service. There would be an advantage in having an experienced agency or commission carry out such regulation. There would be an important disadvantage in subjecting the firms to continuing regulation by separate authorities. It would seem on balance to be the better choice for cable television regulation to remain with the Canadian Radio-Television Commission. Proposed rates by new applicants are already one aspect of an original application examined by the Commission. It may be considered a question of emphasis that there be a more searching review of rates and earnings performance.

Problems of Conflict of Interest

1.13. There is already some present and a good deal more prospective rivalry with computer services firms from computer hardware manufacturers, communications carriers and a number of otherwise unrelated organizations, such as banks, insurance companies and universities, which have their own inside computer installations, often with excess capacity relative to their internal requirements. The possibility of predatory pricing, whether by intent or only by effect, is great. If services are shortly brought within the ambit of the Combines Investigation Act, a far more persistent and continuing enforcement than heretofore would be a necessary, though perhaps not sufficient, condition to assure prevention of any predatory pricing. The continual monitoring of the relevant prices and their impact will prove most difficult. If services remain outside the effective reach of anti-combines legislation, an alternative means of preventing the destruction of otherwise viable Canadian computer services firms must be sought, assuming that there is a public goal of promoting, or at least not hindering, the development of data processing within Canada. It can be argued that such development must proceed for two reasons:

(a) Matters of Canadian security, both national and individual, require that certain data can neither be stored nor processed outside the country to guarantee that Canadian law can be made to apply where desired by Canadian authorities.

(b) Undue risk is assumed by placing too much reliance

upon foreign expertise in data processing for achieving more economical results in Canadian industry through applications of computer technology. Canadian productivity gains would depend too much on foreign decisions.

1.14. Both main-frame computer manufacturers and telecommunications (or local communications) carriers, if they also provide outside, commercial data processing services, are able to place their rivals who are at the same time also their customers, that is, independent data processing firms, in a serious and potentially damaging price squeeze by simply charging "too much" for their equipment or services to their data processing rivals and "too little" to the users of their own computer services. It is easier to cope with this problem regarding regulated carriers than in the case of unregulated computer manufacturers. The latter situation seems to require some kind of anti-combines approach, more immediately effective than has been evident in the past--at least as swift and sure as an effective injunction or order for specific performance at the very outset of hearing an initial complaint. There would of course need to be a penalty provision to deter, indeed minimize, unfounded "nuisance" complaints.

1.15. The public interest is likely served more effectively by varying the extent of regulatory intervention according to the circumstances in individual industries than by a rigid adherence to the dichotomy of all regulation or no regulation. For example, regulation to safeguard the public interest in an efficient and dynamic Canadian telecommunications industry could run from rather complete surveillance of common carrier

activities to little more than general legislative declaration of a national interest in related industries and in their interconnections with mainline communications companies. Remote access data processing is an important ingredient in the communications mix of a growing number of businesses. It is important that the computer services firms that provide the data processing are assured protection against conflict-of-interest market conditions. These arise to some degree whenever a supplier is also engaged in the same business as his customers. In the case of a common carrier, such as the CN-CP ownership interest in Computer Sciences Canada Limited, there is the further undesirable effect of an extension of market power derived from the protected carrier industry into another field which itself seems to call for little or no regulation. The public interest is here reliably safeguarded by confining the activities of regulated carriers to straight transmission and thereby reducing the need for wider regulation. In the case of computer manufacturers engaging in data processing, there would seem to be slight prospect of intervening in a similar fashion. However, some protection of the rights and service priorities of their unaffiliated customers, who also face the manufacturers as service rivals, can be obtained by a strict requirement that the manufacturers incorporate separate subsidiaries to handle all computer services and give separate detailed financial reports. Although such subsidiaries cannot be expected to be thoroughly independent, their establishment is at least a step in the right direction.

1.16. A grant of access to public rights-of-way is necessary for local distribution of electricity, telephone connections and cable television.

It is clearly uneconomic to duplicate routing or facilities, such as poles, that can be used in common by more than one organization. An exclusive right of access, denying entry to others, would create an unnecessary barrier to greater utilization of whatever facilities are required for any use. Public regulation of cost sharing is essential to ensure that priority of use of a public right-of-way does not become the basis of exacting a monopoly tariff. Some communicatons carriers now have a direct or indirect interest in the operation of cable television networks. The present state of technical and market developments provides no overriding argument for excluding independent cable television operators, when they are available. This conclusion could be subject to change at some time in the future depending on the direction of subsequent technical developments. In the meantime, the initiative of independent operators has led to an earlier introduction of cable television than was offered initially by the common carriers, whose primary concern is basic telephone service. The rapid growth of cable television, and future prospects for more general purpose cable systems, make it essential that current policy maintain a number of avenues for future applications of cable television. As noted elsewhere, there is now an overriding argument for proper regulation of rates and standards of service in both communications and cable television, since there is clearly a monopoly franchise in each case. A clear declaration of the public interest in maintaining opportunities for innovation in Canadian telecommunications is necessary to dispel any notion that existing corporate arrangements should somehow be allowed to continue in perpetuity. Future development and changes as they appear desirable would then

presumably be the outcome of a combination of private initiatives and public policy decisions.

1.17. The supply of main-frame computers comes from a small number of foreign manufacturers, one of which occupies a dominant position. There are more sources of supply of peripheral computer equipment, suggesting somewhat more competitive circumstances facing buyers.

1.18. Recognizing the difficulty in dividing manufacturing more finely than published data of the Dominion Bureau of Statistics, a reasonably careful estimate of the degree of concentration and the concomitant extent of buyer choice would rank different sectors in this approximate order of decreasing concentration and increasing buyer choice:

Main-frame computers
Electric wire and cable
Auxiliary computer equipment
Electronic components and devices
Modifying attachments.

Going beyond manufacturing would mean adding telecommunications at the top of the list and computer services at the bottom.

Market Potential

1.19. A May 1969 survey by the Dominion Bureau of Statistics of household facilities and equipment has provided estimates of the household distribution of television sets and telephones, as well as many other items.

Number of households	5,514,000
Households with one or more TV sets	5,293,000
Households with one or more telephones	5,177,000
Households with TV and telephone service	5,035,000

It can be estimated from these figures that there are 5,435,000 households with either television or telephone service or both. These communications systems afford very high coverage within Canada. The establishment of a flexible, general purpose, two-way system based mainly on telephone networks would require considerable additional capital outlays to upgrade local distribution networks and for further household equipment installations. A similar system based mainly on television would also require substantial capital outlays for both outside and inside modifications. Although it seems probable that the mixture of "system" expenditures and "household" expenditure would differ in each case, it would be much more difficult to estimate which is the more economical choice. Technological advantages of one means over the other could of course compel the development of the higher cost system, if the technical advantages were judged by appropriate regulatory or political authorities to be worth the greater cost.

CHAPTER 2

THE NATURE OF THE PUBLIC INTEREST IN TELECOMMUNICATIONS

2.1. An industry as pervasive as communications gives rise to no single and clearly identifiable public interest but rather to a complex set of different and contending interests. Among these, the interests of consumers or final users are often presented with little force or conviction because of a dearth of informed and articulate spokesmen. More specific interests in one aspect or another of an industry are frequently presented with great effect by experts. It is the essence of "public spirited" regulatory processes that the delicate balance of opposing forces be maintained, giving a subtle bias in favour of consumer interests that recognizes either their more weakly made arguments or the deficiencies of the market place as a supplementary self-regulating mechanism. Whereas significant market imperfections may delineate rather clearly the boundaries of industry sectors to be regulated, so relative silence on behalf of final users may reveal rather sharply those areas calling for a subtle "extra" concern on the part of regulators. It is in that context that the public interest in various aspects of telecommunications is considered.

Standards of Service

2.2. Communications facilities ought to be available in sufficient quantity to meet reasonably predictable demands and thereby to avoid any significant queueing problems. A balance must be struck between user preference for no waiting whatever and the carriers' interest in

avoiding the ill will which waiting might cause and the higher costs of having the capability to handle all peak traffic and hence of operating much of the time with considerable idle capacity. It is far from clear whether customers would be willing to pay much higher rates to avoid short delays in service.

2.3. There seems to be little evidence of shortages of Canadian communications facilities of the order of magnitude now experienced in a number of congested areas in the United States. However, given the substantial magnitude of single capital installations in the communications field, it is more difficult to assess the degree of temporarily unnecessary idle capacity. That is, it is difficult to determine whether users would prefer a lower rate-longer wait combination than they now face. In any event, new investment decisions have been private decisions by the carrier organizations themselves, presumably on the basis of their own interests and priorities. Such capital decisions are not now made within a framework that *requires* advance ratification by appropriate public authorities. In those circumstances a carrier could see a positive advantage to itself in expanding capacity far ahead of market demand in order to stake a claim to new or growing markets. That could of course create idle capacity in the economy and thus impose higher costs. Without necessarily implying undue excess capacity, it must be noted that the decision by CN-CP Telecommunications to build a second Canadian microwave network was a corporate decision made in the absence of appropriate regulatory surveillance. Given their duopoly environment, it is reasonable to expect corporate decisions to forego stake-out investments only if there is a regulatory programme for approval or

rejection of company-initiated capital projects and for reasonable assignment of market areas. There would then be more assurance of efficient use of capital.

2.4. Within the possibility of an overall adequacy in the amount of facilities available, there is a subsidiary question but one of great importance to many users. That concerns the minimum amount of service that a carrier requires a customer to take. Time-sharing and channel-sharing might conform much more closely to a customer's needs than twenty-four hour service and full channel width allocation. Setting aside for later treatment cost and pricing matters, the provision of more service than is demanded by customers does represent a wasteful resource allocation for the economy--a source of Canadian inefficiency in an industry that affects the costs of operation of all industries. In the absence of the quite extensive and extended survey that would be needed to determine the extent of the supply-demand discrepancy, it is nevertheless possible to state that a number of users are provided with more time and/or channel width than suits their requirements. Telpak is a private leased line service offered by telephone companies that illustrates the issue of divisibility of services. Although its sixty-four line, twenty-four hour package is a good accommodation of some customers' requirements, several subdivisions of a similar service would adapt the system more closely to the needs of many more customers. Another example of service divisibility is the need of low income households to have a minimum telephone service at low cost--basically a system connection for emergency use. Whether that is handled as a special welfare provision or not, there seems to be a strong case for

an optional service at low monthly cost and allowing few calls without extra charge. It is of course essential to return to this question under the heading of costs and prices.

2.5. The existence of two communications carriers in Canada raises special problems characteristic of duopoly, problems that are more rather than less complex than the pure monopoly issues. The two systems are dissimilar in certain services they offer and so similar in other cases that their offerings can be regarded as reasonable alternatives for a good many customers. The argument for letting market forces be the regulating mechanism in such cases is by no means convincing. In spite of some common market areas, the two carrier systems are not operating mainly in matching franchise areas but in separate markets. In their common market areas an intelligent assessment by them of their market interdependence is most likely sufficient to have them establish and hold to rate levels that are all too like those that would be chosen by an unregulated monopoly. A regulating commission has the task of setting prices that are closer to unit costs. Because the growth of two firms instead of one tends to exert more cost-increasing influence, the commission's task is more difficult but not less urgent than in their separate market situations.

2.6. As the overall capacity of the two-system Canadian network becomes nearly fully utilized, it is improbable that private decisions will result in the necessarily large capital addition being made to only one of the two systems. That would mean the other company would be deciding to forego its share of the expanding demand for communications services. To the extent that a greater measure of national security is achieved

by having different operators rather than simply a single operator with two physically separated systems, the higher level of excess capacity is properly considered a defence cost. It is not easy to see how different operators contribute to national security or indeed to ordinary system reliability. These objectives seem to be met by the creation of physically separate routes and by the use of different modes of transmission--pole line, buried cable, microwave, satellite, etc. The issue would appear not to touch upon the choice of one or more operators.

2.7. The quality of transmission services provided by the communications carriers ought to match rather closely the various requirements of their customers. Traditional telegraph and telephone facilities seem to pose no serious problems in that regard. Telephone transmission terminals are typically on the premises of customers, while telegraph terminals are not. That has meant persisting annoyance and some inconvenience to telephone users because of restrictions, indeed in many cases prohibitions, on the use of so-called foreign attachments--terminal devices not supplied by the companies. It can be argued that a user of switched transmission services offered by a communications carrier is in fact obtaining inferior or unsatisfactory service if that carrier forces him to forego the use of the most suitable terminal equipment available, so long as it is at the same time technically compatible. That quality issue--the required use of somewhat unsatisfactory attachments having the effect of downgrading the quality of the entire message-sending process--now appears to be gradually resolving itself by some relaxation of carrier restrictions, a change in the desired direction of equipment use being determined by technical

compatibility and user choice.

2.8. There is also a strong public interest in achieving the most efficient use of transmission facilities. Recently developed terminal equipment, such as multiplexing units, makes possible both more economical and more flexible use of communications circuits than can be provided by a terminal combination of telephone set and audio coupler. The substantial cost savings are a persuasive economic argument to implement the necessary regulatory directives which might involve circuit upgrading and presumably downward rate revision. Acceptance of carrier-imposed prohibitions against the use of the most effective attachments is unsound public policy. Regulatory authorities must assure technical compatibility as the condition for customer use. Whatever revenue-protecting elements are present in any policy of restricting so-called foreign attachments fail to constitute a valid defence for the restrictive policy. Regulatory authorities must not allow inefficient resource use as a means of enhancing carrier revenue.

2.9. Private leased channels for data or voice-data transmission are offered by both the "telegraph" system and by the "telephone" network. Customer problems concerning the attachment of the most appropriate linking, switching and terminal equipment are of greater importance because their more sophisticated transmission requirements are seriously affected by the use of more suitable or less suitable ancillary devices. It is less clear that carrier relaxation of anti-foreign attachment rules is proceeding quickly enough to be considered progressive enough for the data services industry and indirectly for the customers of data processing firms.

2.10. In summary, the public interest in Canadian telecommunications is to maintain:

(a) Its most efficient use--maximum use for minimum investment.

(b) Adequate and progressive development of supplier service industries--wire and cable, etc.

(c) National defence requirements.

(d) National scientific and industrial prestige.

(e) National unity through more effective social and cultural exchange across the country.

(f) International competitiveness by increasing productivity through more efficient communications.

(g) Sufficient idle capacity to avoid serious queueing at times of peak traffic.

(h) Overall system usage at a level high enough to assure that unit costs remain relatively close to the attainable minimum.

(i) Standards of quality satisfactory with respect to important customer needs.

(j) A pace of modernizing and upgrading that will inhibit as little as possible, giving some consideration to costs, the growth in Canada of the most progressive applications of voice, picture and data processing and transmission.

(k) The organizational structure in a form that advances technology, especially by responding

with little delay to changing needs. That means a responsiveness to all customer demands, including such features as satellites and satellite ground stations for both national purposes and international use.

<u>Equal and Reasonable Access</u>

2.11. The vast geographic extent of the country and the attendant dispersion of population make telecommunications an especially vital factor both in economic affairs and day-to-day individual contacts in Canada. It is important to the prosperity and development of the country that as few Canadians as possible are disadvantaged by outmoded and inefficient communications. It is important that equitable access to adequate facilities be as widespread as is consistent with acceptable levels of cost. The likelihood of differences of opinion is apparent. The amount and quality of communications services and the pace of adapting to changing user requirements are questions for regulatory decisions. Market power is too unevenly distributed between carriers and customers to permit the unhindered play of market forces.

2.12. If some aspects of establishing general and appropriate access to telecommunications services seem clearly to involve significant cross-subsidization--users of certain classes of service or geographic groups of customers paying more than justified by costs in order that others may pay less--that method of exercising what is actually a taxing power should undergo a searching examination. It could well be that a

preferred policy would impose a more explicit and direct subsidy on specific classes of service or to particular groups of customers or, possibly, a subsidy to carriers in conjunction with and conditional upon the establishment of appropriate rates. That would of course transfer the burden of subsidizing from those who happen to be "subsidizing" customers to Canadians as taxpayers to one or another level of government. Any determination that cross-subsidization by one means or another is desirable ought to be made explicitly by regulatory authorities and not by the carrier companies themselves. It is doubtful that the firms have actually wanted to be in the position of having to make decisions concerning what are in effect transfer payments from one customer to another. The regulatory decisions would best be made within a framework of legislative guide lines or principles regarding cross-subsidization.

2.13. Allowing some weight to cost considerations, there seem to be none the less a number of cases of cross-subsidization between both classes of service and groups of customers. The relatively more burdened users face a restriction of their use of communications that represents a misallocation of the economy's resources, to the extent that their higher rates are not fully justified by higher costs of providing the services they are using AND want. These situations should be subject to regulatory scrutiny under legislative guide line or to specific legislative approval. It would represent a minimum requirement for carriers to have to demonstrate actual costs wherever there is apparently a case of cross-subsidization.

2.14. There is also a vital concern that manufacturers and suppliers

of all kinds of communications equipment and wire and cable have open market access to carriers and their users. In other words, competition on price and quality can improve the efficiency and the continuing adaptability of Canadian telecommunications services. If the markets are open and neither foreclosed nor seriously impaired by intercorporate relationships or contractual arrangements, there are greater prospects of improvements being more quickly introduced into network operations because of a wider variety of sources of new ideas. As well as the increased probability of more rapid innovation, more effective competition tends to exert downward pressure on the supply prices.

2.15. For example, the Hong Kong Telephone Co. Ltd., a private shareholder company that operates a system experiencing an annual growth rate of twenty per cent, uses a world-wide tender system in its acquisition of new equipment. Its most recent 60,000-line electronic exchange was made in West Germany; its telephone sets are made in Portugal. International tender is also used by Singapore Telephone, a Crown corporation, in obtaining equipment and cable. That other factors than price are given some weight is seen in the recent decision to have switching equipment produced in Singapore by a joint venture of Swedish L.M. Ericsson and Singapore businessmen. A somewhat different approach is seen in the policy of the British publicly operated system. The main purchasing is from major English manufacturers, a minor part from smaller English firms and about ten per cent from world markets.

2.16. If arguments in favour of maintaining the vertical integration that now involves the two largest telephone companies are to be accepted, there remains the separate question, arising from that vertical integration

(Bell-Northern Electric and B.C. Telephone-Automatic Electric-Lenkurt), of the extent to which substantial portions of the Canadian communications equipment and wire and cable markets are denied to independent Canadian manufacturers. With few exceptions, Northern Electric is a major supplier of many equipment and wire and cable requirements of parent Bell Canada and associated telephone companies. An important exception is the Lancaster, New Brunswick, plant of Canada Wire and Cable Co., Limited, which makes substantial sales to New Brunswick Telephone Company and Maritime Telegraph and Telephone Company. However, since the general situation regarding the two major vertically integrated corporate telephone systems is one of limited access by independent suppliers, the United Kingdom policy may afford a next best procedure to promote the development of Canadian telecommunications manufacturing by several firms to assure some meaningful choice of equipment. At the outset it should prove relatively easy for the integrated systems to use some independent Canadian sources of supply, where competitive, for more standardized items. Subsequently there could develop a realistic opportunity for independent manufacturers to participate in custom supplying on contract. The appraisal of the value to the Canadian economy of such changes would of course be a regulatory responsibility.

2.17. The possible administrative ease afforded to carriers by obtaining supplies from related companies is offset by the possibility of a carrier imposing on its related supplier higher manufacturing costs (last minute design changes, etc.) and of imposing on the regulatory authorities a far more complex task. Avoidance of the complications

with regard to "allowable" costs by any regulatory decisions not to examine the less-than-arm's length transactions tends to defeat the basic purpose of assuring that the public interest in efficiency and correspondingly low rates is being guarded. The possible developmental advantages derived from vertical integration could be otherwise achieved and do not in any case appear to be overwhelming. The direct Bell-Northern Electric shareholding and market relationship may tend to afford slightly more advantageous developmental opportunities than are found in the case of British Columbia Telephone. In contrast with its direct supply relationship with Automatic Electric and Lenkurt, the ownership connection is that they are all controlled by the same company, General Telephone and Electronics Corporation.

2.18. Two further examples of corporate integration may be recalled--CN-CP Telecommunications in the computer services industry and telephone companies controlling the physical networks of cable television companies. The latter case could result in independent manufacturers being denied access to that part of the cable market which could be open to them if cable television companies controlled the cable installations. Short of a thorough study of the integrated relationships, which might or might not reveal that there are pressing policy problems because of the outcome of those relations, a warning must be given on at least three counts:

(a) Costs may be higher than would otherwise result because of the performance in the unregulated but associated companies.

(b) The partially or principally closed markets may

be imposing too serious a growth restraint on independent companies in the supply industries. It must be noted that the restriction is an extension of the market power of carriers that is inherent in their monopolistic position.

(c) Wherever a vertically integrated company is both a supplier to and a competitive rival of another company, it has the opportunity to impose a damaging price squeeze on its rival. The history of restrictive trade practices gives enough examples of its occurrence to show that it is often a problem.

2.19. Since service standards, customer access to communications networks and supplier access to communications markets are inextricably tied in with pricing practices, further examination of these matters will be given under the topic of pricing.

Non-Discriminatory Pricing

2.20. An unregulated profit-maximizing firm will set its prices to different customers (whom it can keep separated) and its prices for different kinds of services according to the different demands. That is, it will obtain the greatest total profit possible for any given level of sales by charging across the board the value of service. No user will of course pay more than the value to him of a particular service. Value of service is the upper limit of attainable prices--it

is the value according to the potential buyer--regardless of the degree of monopoly power. No buyer will pay more and no buyer will pay that much if he knows of a cheaper alternative supply open to him. That is, some degree of monopoly power and separated groups of customers are necessary to be able to discriminate. For discrimination to bring gain to the monopoly, there must be different demand responses on the part of various customers or groups. Because it is not possible (or at least too costly) to isolate each individual customer, monopoly pricing limits are a set of most profitable price and output combinations in the different markets. They establish the highest prices that are attainable, given the particular market demands and the objective of maximum profit. That is the value-of-service upper end of the pricing spectrum.

2.21. Private firms that operate in competitive markets are restrained from realizing those highest possible prices to the extent that competition is effective. Private firms in regulated industries are restrained from realizing those highest possible prices to the extent that the regulators are effective and are not permitting price discrimination for other purposes. Rate differences or similarities that do not correspond to cost differences or similarities result in _discrimination_ and in some sense are "unfair". The realization of prices more related to value of service than to costs requires a significant lack of competitive forces, ineffective regulation or approval by regulating authorities and significant differences in demand. If other purposes, except authorized cross-subsidization, are to be served by price discrimination, that should rest upon legislative edict. Measured against the competitive norm, discriminatory prices are unfair and call for explicit

legislative approval and an effective appeal mechanism by which aggrieved parties may seek redress.

2.22. The long-term lower limit to a specific rate is the long-term marginal cost of that service, if it is at least as high as the average cost. Aside from the difficulty of measuring individual costs because of the necessarily judgmental apportionment of common costs, another problem is faced wherever there are decreasing costs. Marginal-cost pricing of such a service would not recover its average cost and hence would mean in some cases that offerings of that service at such a price (equal to marginal cost) would not be a viable proposition. The cases that would be viable are those where the lower limit price is above average variable cost, although less than total cost per unit, and thereby makes some contribution toward covering fixed costs. If that service would not be taken by customers at higher prices and the overall facilities of the carrier would hence be less fully utilized and <u>rates for other customers or kinds of services are not increased (or prevented from declining) as a result</u>, the effect of a less than fully compensatory price could be to afford an overall benefit (more services available) and to impose no hardship on other users or classes of service. That line of reasoning may be tenable in the short run. It will not stand up, however, if the rates charged for all other services are yielding only the normal, allowed rate of return. A less-than-average-cost price on one or more services would mean that the overall system rate of return would then be below normal. In other words, in order to maintain the regulated rate of return, one or more specific rates would have to contain an element of value-of-service pricing to offset the

less-than-fully-compensatory price.

2.23. Regardless of the purpose of any such low rates, they have predatory pricing effects on new entrants and on private systems. In the long run the only acceptable pricing policy is a fully compensatory one. Lower rates are sustainable for perhaps a short time but clearly not in the long run.

2.24. Since there is a public interest in allowing no more than an adequate overall rate of return as well as in establishing a set of specific rates that pass the test of cost justification, a reasonable apportionment of common costs and a continuing and careful surveillance of individual rates are needed. Regulatory authorities must satisfy themselves, and indeed communications customers and the public, that costs are appropriately allocated and that specific rates are cost-related. In cases of rates below total cost per unit for the service involved, the regulators should require that there are not some offsetting "too high" rates elsewhere in the system, unless they are expressly approved by the regulators for good and sufficient reasons. In cases of rates tending toward the upper limit of value of service, the regulators should assure themselves that no individual rate is contributing more than its share, in the judgment of the regulators, to the acceptable overall rate of return. The separation of costs that is necessary for effective regulation must be undertaken by the companies but must be most rigorously examined by the regulators. The protection of the public interest rests ultimately in the hands of the regulators, not the companies.

2.25. On types of service or items of equipment which may be deemed

"optional", "not necessary", "luxury", some would agree that their rates ought to be unregulated. That might lead to price levels approaching quite closely the attainable maximum--the value of the service or device to the customer. That would of course mean that the unregulated rates in those cases would be subsidizing the basic services and equipment. On the other hand, if a carrier were to decide to adopt a market penetrating policy of prices even below full costs but yet above variable costs, the impact on the finances of the system would be less clear. The optional service rate would be contributing something to company overhead but, from some points of view, less than its "proper" share. The considerable difficulty in experimenting with prices in an environment of regulation would seem to be some deterrent to market-penetration pricing and would seem to create a tendency to move in the direction of value of service, however imprecise that price may be. Sound policy will adhere to the principle of regulating the prices of all services, including luxury and new, on the basis of fully compensatory individual rates, except for an authorized exception. The carriers may initiate proposals for special rates but they must ultimately satisfy the regulating authorities to obtain approval. A distinction can be made on general welfare grounds between a high pink phone rate and a high rate for an isolated and remote subscriber with no reasonable alternative. Nevertheless, all rates should be regulated to prevent the monopoly power extending beyond the scope of regulation.

2.26. The public interest in preventing a private company exerting whatever monopoly power it possesses to advantage itself and unduly disadvantage its customers argues that any decisions regarding the

relative discrimination between rates must be subject to the close scrutiny of the regulating authorities and to their approval or rejection. It is by no means probable, although it may be possible, that regulators face a practically feasible task unless they have the power to regulate all the activities of a firm with substantial monopoly power. The mere preparation by a carrier to enter a new activity imposes cost increases on existing activities, most of which are presumably in the main regulated. Personnel must be hired for the new ventures or diverted from attending to current activities. It ought to be a matter of public policy to choose the pace of modernizing and expanding conventional services and also which new fields related to communications are to be entered--when and by whom. Complaints are made here, and there are striking examples in the United States in such places as New York City that the fundamental telecommunications networks on both sides of the border are displaying enough signs of inadequacy to support the case for confining the carriers solely to the communications business. Their entire energies and resources of personnel, equipment and capital-raising ability could then focus on the maintenance and improvement of the basic systems.

2.27. As more sophisticated uses of communications are an important factor in data transmission, there will be frequent issues concerning what new devices are essential upgradings of the network and what ones are "luxuries". For example electronic switching and touch-tone telephones could be regarded as luxuries for a straight voice message customer. With regard to data or voice-data transmission they would represent a minimum upgrading for some customers' requirements.

Conventional dialing and older switching techniques impose serious barriers to realizing the full capabilities of data services. In the public interest of having the Canadian economy keep pace with technical advances elsewhere, as one aspect of achieving competitiveness with other countries, innovations must not lag too long. For example, if a carrier were inclined to delay, as the result of a quite rational study of the net gain to itself, the introduction of, say, a cost-reducing innovation, regulating authorities might have to require an earlier introduction and decide the new rate-cost structures to serve the developing needs of users and to protect the financial health of the carrier. Regardless of initiatives from the companies, the regulators must be capable of making an opposite determination in the public interest.

Infrastructure and Productivity

2.28. The infrastructure characteristics of telecommunications are sufficiently strong to raise public policy issues that have been often faced in Canada. Railroad building has had from time to time both public subsidizing and regulating on the grounds of national interest. The provision of electric power in Ontario by a public organization instead of a private shareholder company involved several points, at least two of which are worth mentioning. The extension of the power grid likely proceeded more quickly than would have been feasible for private firms. Lower priced electricity would likely have the useful attribute of promoting the economic growth of the province. Other examples could be cited.

2.29. That analogy is made not so much to propose direct public subsidizing of communications facilities as to suggest that wherever it is determined to be desired public policy to introduce a new service so also should it be a matter of public policy to finance whatever aspects would be neglected by the private carriers. If some compromise between conflicting interests, including discriminatory rates and cross-subsidization, is called for, their resolution should be accomplished by regulatory or political authorities, not by private firms. Most decisions thus far have come from private initiative. The extent of discrimination involved is not clearly known because the separation of revenues and costs necessary to assess how many and how serious are the departures from non-discriminatory pricing, has not been made. A step in that direction has been made by the Canadian Transport Commission in its 1969 Order requiring Bell Canada to separate its costs and revenues between regulated and unregulated services. The eventual submission of that cost and revenue separation will be of little assistance in the task of determining the extent of price discrimination for each service offered by that company. That is the information necessary for the Commission to establish reasons for permitting or denying discriminatory rates. It would be unreasonable to expect its members to decide upon matters they cannot presently know. It would be reasonable to expect them to obtain the information they need. The rights of other Canadians in non-Bell territory will not be directly protected without similar cost and revenue separations for their communications carriers. If the expense of making the separation seems high relative to some rough estimate of the unfairness of whatever discrimination there may be, an

application to other systems of what is discovered regarding Bell Canada might be a great improvement over no criteria.

2.30. It is axiomatic that the costs of communications services should be held at the lowest levels possible because communications have such a pervasive impact throughout the economy. As there has often been more public concern about steel prices, steel being an intermediate good, than about automobile prices, some would express more concern about the rates for communications services used by business than for the residential telephone. The viewpoint concerns economic efficiency. The viewpoint of keeping public consent might lead to an opposite conclusion. A number of the most recent and most advanced uses of telecommunications has been a vital link in data processing--a link of crucial importance to permit the most effective use of computers. These rates have in the main been negotiated and seem clearly to have been strongly influenced by the discriminatory value-of-service principle.

2.31. If carriers do face decreasing unit costs in the ranges of output where they are likely to continue to operate, there will in general have to be recognition given to setting prices, approved after intensive examination by the regulators, high enough to achieve full cost recovery for the system.

2.32. In order to provide generally uninterrupted service and to limit waiting time for service, standby facilities and excess or idle capacity are required. It is a matter of judgment as to how much extra capacity, and the necessary costs associated with that, is sufficient. The carrier companies can best decide what facilities are needed for any given level of reliability and quick access. Because there are different

levels of cost related to different standards of service, the regulating authorities must play an active part in choosing the standards to be maintained. Dissatisfied users will seek out the carriers for redress. It is therefore essential that a simple and inexpensive complaint route be open. There is a distinction, which must be brought home to the users of communications services, between failure on the part of the carriers to meet the established standards and failure on the part of the regulators to set adequate standards. Communications customers could also benefit from a simple complaint system regarding the standards set by regulation--simpler than the usual rate hearing. The level of service satisfactory at one time is unlikely to remain satisfactory in the face of rapidly changing needs.

2.33. Improvements may often be sought by the carriers themselves and the assessment of their suitability must be swiftly made by the regulators. If, on the other hand, user complaints are indicating fairly clearly that the carriers are laggard, those complaints should energize the regulators into a compelling conference with the carriers.

2.34. The capacity requirements to handle peak traffic call for efforts also to be made to reduce the peaks. Differential pricing can lead to some shifting of traffic, although hours of business influence the timing of much of the voice and a good deal of the data transmission. Whatever price differentials are selected that might smooth out some peaking should be introduced so as to shift revenues earned by the carriers for different services rather than to affect their total revenue.

2.35. It must be acknowledged that high and low traffic periods will persist and will require a trade-off between the higher costs of

maintaining sufficient capacity, idle a good deal of the time, to assure as immediate service at peak periods as at other times and an acceptable, in view of lower costs, waiting time during peak traffic. The regulating authorities ought to play an active part in decisions regarding "adequate" facilities if only to ensure that users are not obliged to pay significantly more than they would prefer for a somewhat inferior service because the carriers prefer a standard of service that their customers consider too high--that is, not worth the price.

2.36. The swiftness of introducing new techniques and new services or networks affects costs. Some changes may be cost-reducing; some will be cost-increasing. Care must be exercised so as to distinguish between new techniques or networks to handle existing services and new services, whether handled by existing equipment and networks or by new systems.

2.37. In the case of a cost-reducing change in the handling of an existing service in a part of the company's entire system, there is the question of assigning the benefit to that set of customers or to all customers of the same service. As a matter of incentive, the regulating authorities could determine how long the company ought to be allowed to enjoy extra revenue by reason of not reducing rates. That would, however, frustrate the basic objective of setting the overall rate of return. A higher rate of return ought not to be permitted as a matter of policy, even on a temporary basis. Although users and suppliers are by no means without knowledge of and competence in the rapidly advancing technology of communications, much of the task of maintaining up-to-date telecommunications will remain with the carriers.

Their recognition of the fact that, aside from errors, their regulated environment commits them to a more secure but limited rate of return might make them reluctant to introduce innovations. They might react to too little incentive with too much inertia. It is essential that the regulating authorities are prepared to intervene for at least two reasons. First, a carrier company might otherwise fail to pass on realized cost reductions to its customers or to the proper group of customers. Secondly, a carrier might need to be directed to introduce significant technical improvements. The regulating authorities would order the company to undertake the investment required for the desired changes and would at the same time establish specific rates that would assure the approved rate of return. An element in regulatory decisions must be an appraisal of market demand. Disquiet on the part of a number of customers with highly specialized service requirements suggests that innovating has not always kept pace with technological possibilities or with changing demands for services.

2.38. It is improbable that the management of a common carrier can devote the necessary time and energy and bring to bear the requisite expertise in order to upgrade facilities at a rate satisfactory to a few customers, whenever that particular service is a quite small part of its overall business. It would be inappropriate to induce more attention to such problems by permitting high rates, tending toward the value-of-service ceiling, because of a decision not to regulate. It is too likely that such a policy would lead to an impairment of other sectors of the Canadian economy through the imposition of unduly high costs of communication.

2.39. If higher costs result from the introduction of new services or significant changes in existing services, there is again a similar problem of answering the question of who is to pay--particular customers or users of the affected service or customers in general. The guardians of the public interest, the regulators, must be ultimately the deciding influence.

Innovation

2.40. Efficiency and innovation are strongly interrelated in circumstances that include important elements of rapidly changing technology. Telecommunications carriers themselves and certain of their customers, such as data processing firms, are clearly functioning in such circumstances. When new equipment or circuit facilities that will lower operating costs become available, carriers face the problem of when to introduce the innovation as replacement for less efficient facilities now in place. It is less difficult to adopt the innovation for net additions to the company's capital in place. Financial incentive, customer dissatisfaction and regulatory insistence may each influence the rate and kind of innovation.

2.41. Differing time horizons of carriers, users and regulators will often bring them to different conclusions regarding the optimum rate of displacing obsolete or obsolescent facilities. The differences in judgment are likely to be especially wide in cases where the less efficient equipment in use has required a substantial capital outlay and its operational life, apart from technological displacement, is

considerable. The notion of sunk costs is not everywhere popular. An argument by a carrier to defer the introduction of a specific innovation on the grounds that it seems to have immediate application to the needs of only a small number of the users of telecommunications is an argument for considering the costs and benefits of establishing a separate network for such specific purposes. It is the responsibility of the regulating authorities, if the public interest in the maintenance of an up-to-date system in Canada is to be safeguarded, to so examine the issue.

2.42. Should it be their judgment that the costs of a separate network for specific rather than general use would be too high in terms of the estimated benefits, the corollary of that decision is that the regulators direct the carrier to innovate and to price the service on a cost-related basis.

2.43. There are a great many changes in and additions to the Canadian telecommunications networks that will mean new installations of presumably more advanced technique alongside older and less capable circuits as well as higher capacity installations sometimes eliminating out-of-date facilities and yet increasing the overall capacity of the system. That combination of adding and replacing channels will take place on the routes already nearest capacity use and those where traffic is growing most rapidly. That will not necessarily lead to discarding earliest the most obsolete equipment. It is also not necessarily the preferred policy in all circumstances that the discard and upgrade priority should be the "worst" facilities out first.

2.44. For example, some important data transmission requirements are

nationwide--important to the data processing companies and important to Canada. That calls for a national, switched, high quality, high speed, low cost voice-data transmission system designed to be well suited to such needs. That will give greater assurance that Canadian business will not be forced to lag in realizing as far as possible current computer capabilities in increasing business efficiency. It will also link together more effectively various areas of the country. If regulatory intervention is a prerequisite to the establishment and continuing operation of a network more closely adapted to data transmission earlier than it would occur by carrier decision, then the intervention must be made in the public interest.

2.45. It may be noted that the undertaking of innovative risk by a regulated carrier can be distinguished from the risk-taking of an unregulated firm because of the allowed rate of return under regulation. The distinction is sharper with respect to an innovation designed to meet specific customer requirements because of greater reliability in estimating future use. If the regulating authorities have allowed, or in some instances required, the innovation as a reasonable capital outlay in response to user representations, there is a high probability that the carrier will realize the allowed rate of return. That greater assurance of the financial success of an innovation reduces the importance of special incentives as an inducement to innovate.

2.46. The public interest in promoting Canadian expertise in telecommunications presents some difficulty. Although it is clear that such promotion must involve Canadian personnel, that can be accomplished by awarding supply contracts to Canadian owned companies in the country or

to Canadian based plants of foreign owned companies, or by obtaining supply contracts for Canadian manufacturing facilities from foreign ventures. Wherever Canadian participation on either level appears to mean higher costs, the decision is in part political, whether the ultimate responsibility is retained by the appropriate political authority or assigned to some duly appointed board. The issue to be resolved has two significant aspects:

(a) If a specific supply requirement represents an opportunity to develop Canadian talent in an area of considerable future promise, proceed.

(b) If the estimated higher costs are justified by what might be deemed an investment in Canadian growth, in other words, if it appears that the extra cost will result in a reasonable future reward to the economy, proceed.

These are political decisions that should be made in that setting. The costs of realizing certain benefits must not only be assessed as to their reasonableness but also as to their appropriate assignments, in some instances, to such goals as defence, national prestige, national unity, etc. Those broad objectives may be the original justification for undertaking projects in the forefront of technological advance. Successful development may sometimes lead to the creation of a new comparative advantage for the Canadian economy. There are pay-offs to risk-taking. The Telesat contract is a recent illustration of the operation of the principle that some telecommunications issues are political and ought to be resolved on those grounds.

Industry Responsiveness

2.47. There seems to be relatively wide agreement that good performance in the Canadian economy would mean going a rather considerable way toward full employment and reasonably stable prices, an equitable income distribution, a high growth rate and a significant degree of competitiveness in world trade. There is less agreement concerning priorities among these goals and there are differences of opinion regarding what is sufficient in each instance. For example, debate is continuous on the topic of what unemployment percentage is "acceptable". To assure reasonably good economic performance in each industrial sector, reliance is usually placed on unregulated market forces. The underlying premise is that competition is sufficiently effective to compel relatively efficient resource allocation and to avoid significant maldistribution of income. In the circumstances of continually changing demand, the appearance of new products and services and the disappearance of old ones, and entry and exit of firms, the efficiency needed for good performance requires highly responsive firms and highly responsive markets. Anti-combines provisions are designed to prevent some clear impediments to competition. The competition between independent firms is otherwise assumed to suffice.

2.48. However well or poorly the unregulated sectors perform, there is a strong public interest in seeing that regulated sectors perform as well or better. They are regulated because of a conviction that the social control of competition is too weak to be relied upon. There are costs of regulating, for which the public would like to see an outcome

of responsiveness to changing demand and advancing technology as well as efficient resource allocation and prevention of monopoly profit. If the complexities of regulating both the overall rate of return and the specific rates for individual services interfere one way or another with responsiveness, the regulating authorities must select some resolution of the possible conflict between levels of financial inducement and swiftness of response on the part of the regulated firm. Public direction of quicker response seems to have priority over allowing higher profits in a regulated industry.

2.49. They must weigh the costs incurred by telecommunications companies in order to achieve quick response to the changing requirements of their customers against the costs that would be incurred by the many different users of communications facilities because of failure by the carriers, and implicitly by the regulating authorities themselves, to keep pace with changing user needs. A responsive complaint procedure, fast and inexpensive, is likely to be a useful factor in maintaining a responsive industry.

2.50. In some cases it may be determined by political or regulatory authorities that existing public goals or newly developing public goals are being neglected or inadequately served by or seem to be in conflict with the private decisions of the carrier companies, which are presumably made on the basis of prospective corporate advantage. It will be the responsibility in such cases of the proper authorities to decide that the public objectives will be attained and whether the costs of attainment will be borne by taxpayers or telecommunications users. It must be noted that a particular public goal may or may not harmonize

with the private objectives of communications users when there is already some element of conflict with the private objectives of the carriers. A particular public goal may conflict with the private objectives of both telecommunications users and the carriers. The carriers and their customers may also be in conflict with each other on a number of issues. Such circumstances make regulatory decisions more difficult though not less necessary. Substantial dissatisfaction with some regulatory decisions on the part of users might call for reviewing the decisions but it should not be taken as an argument for extending the area of regulation. The desired responsiveness of the regulated carrier industry is a question of priorities finally determined by public authorities. That does not necessarily ensure that all divergent interests can be equally well served. Sound decisions concerning significant changes or new projects that present a mixture of public and private considerations demand considerable advance liaison between political authorities, regulatory boards and the operating organizations. The determination of the specific proportions of public and private financing of Telsat is an example of the kind of telecommunications decision that should follow a thorough examination of different viewpoints. Carrying out a project with both commercial and non-commercial objectives can certainly be rational even though there may be an extended developmental stage during which revenues would not justify a purely commercial enterprise. The key to an intelligent decision is to specify carefully the degrees of public and private participation. If there are important public policy implications in any new project, a continuing and overriding public influence is essential.

Regulatory Boundaries

2.51. So long as Canadian public policy gives general support to the case for private enterprise operating competitively in open markets, unregulated except for such matters as fraud, it is quite important to attempt to draw well-defined boundaries to mark the areas that are to be regulated. The case for regulation is in the main a case for substituting public intervention (public ownership is an alternative and is in effect in various industries in different parts of the country) for the unhindered play of market forces. That case has usually been made whenever public authorities have been convinced that unregulated firms and markets would be too unlikely to produce the desired outcome of continuous supply adjustment to consumer demands and to technological change. The prospect of monopoly power resulting in certain firms being able to extract a measure of economic rent by withholding some supply from the market and raising the prices of their restricted services has strengthened the argument for public intervention by way of regulation or ownership. The public has some interest in regulatory boundaries because they assist or hinder regulatory authorities to the extent that they are well or poorly drawn.

2.52. The regulatory task is an impressive one. If it is to be a success, the decisions and directives of the regulatory authorities must bring about results that are at least substantially like those obtaining in competitive circumstances that permit no firm individually to affect price but require firms to accept the market price as given. The regulatory task is difficult enough, that the difficulty is itself

an argument for establishing as limited sectors as possible to be regulated in the public interest. That is in effect confirming that the unregulated and competitive part of the economy be kept as wide as possible. When that is not a central theme of Canadian public policy, there would then have to be from case to case a choice between public regulation of private firms and publicly owned enterprises--two different forms of public intervention. Each of the two commercial telecommunications networks in Canada is a mixture of private and public enterprise and is subject to varying degrees of regulation regarding various services. It is far from easy to demonstrate that the publicly owned components of the systems are more chary than their shareholder owned companions of seeking commercial profits.

2.53. Even where they eschew profit-seeking as such, publicly owned corporations are frequently under pressure to conduct their affairs in a businesslike way--possibly including price discrimination. Their pricing decisions are an exercise of indirect taxing power. When a publicly owned company and its regulatory agency are both under the same government, there is a common interest in its "regulated" earnings as indirect tax receipts. In those circumstances stern scrutiny and denial of high rates seem unlikely. Revenue-sharing disagreements among members of the Trans-Canada Telephone System would be especially difficult to resolve in a manner that would also ensure protection of the public interest. They represent a private-public company conflict and a federal-provincial jurisdictional question, as well as a force tending to raise rates. It is fairly straightforward that disputes about sharing larger pies tend to be less acrimonious than those over

small pies. The absence of effective nationwide rate regulation seems to leave the public interest somewhat unguarded. Commercial decisions of publicly owned companies may sometimes conflict with public goals, if only because of a lack of co-ordination. The recent acquisition by Polymer Corporation of a United States computer services firm is an example. That apparently reasonable commercial decision could possibly impair the growth of the Canadian computer services industry by diverting business out of the country. Whether it does or not, the hard policy issue is that there is no adequate surveillance of the implications of such actions. Many of these problems are handled on an *ad hoc* basis, which falls short of establishing policy. Unintended detriment is not less harmful because it results from an unmonitored decision of a publicly owned corporation.

2.54. Acceptance of a principal role in the economy for unregulated private firms is also acceptance of the proposition that monopolistic power be confined or regulated. To regulate partially a single decision-making organization and to leave some of its activities unhindered is to confound the regulatory process. Once the regulatory boundary is held to encompass certain areas, it is essential to the integrity of the regulatory process that a business organization in those areas be confined to there only. As the activities of a partially regulated firm go further and further beyond the regulated field, the public interest confronts a quite unsatisfactory choice--extend the regulatory boundaries to include the expanding areas of the company or accept less and less adequate regulation as that task grows more and more complex. The rational and operative objective is to have the regulated set of

activities and the activities of the regulated firms coincide completely. In other words, anything undertaken by a firm subject to public regulation is regulated and the regulated firm shall not enter fields that are considered better left unregulated. Any significant expansion or introduction of new services by a regulated firm must wait for approval by the regulators.

2.55. An important aspect of confining companies solely to a regulated sector is seen in several relationships they might have with other business concerns. Intercorporate ownership connections, long-term contractual agreements and any other means of modifying open market contacts are close to impossible to oversee and appraise in the public interest. Suffice it to say that the extreme difficulty of public surveillance destroys the acceptability of any such arrangements between a regulated and unregulated organization. A clean separation of activities is at best a mere outside chance. Separate incorporations may add much to the appearance of arm's-length dealings, they add little substance by way of a longer arm, which is the essence of separate, independent markets. A subsidiary of <u>any</u> company, and more so in the case of companies in sheltered markets where some reasonable rate of return is relatively well assured, can charge its parent too much, can be forced by its parent to incur too high costs in transactions with the parent or it can be arranged that some aspects of the subsidiary's activities are quite low profit. Similar arrangements between divisions of a single company are harder to detect, which is not to say they are easy to detect between different companies. To be certain about its decision and their impact, a regulatory commission must be certain about

the detailed nature of the arrangements that it purports to assess in the public interest.

2.56. A captive supplier to a regulated firm, whether captive by ownership or contract, creates special problems for rival suppliers in the same industry as the captive firm. They enjoy no protected markets and are barred from an opportunity to serve a substantial part of the Canadian market, whenever the parent is important in the total, a likely situation in the communications field. This foreclosing of part of the Canadian market for equipment and wire and cable is to some degree inhibiting on innovation, if only by reason of reducing the possible sources of new ideas. If it is to be quite clear that the public regulators are at all times certain of their ground and the public interest is by them fully safeguarded, the boundary limits of the carriers must be defined clearly and firmly. The interfaces with customers which have been so vigorously protected in the past by the carriers themselves provide a sound starting-point for outlining the boundaries.

2.57. A satisfactory version of competitive tender as the means of carriers acquiring new equipment would seem to improve the likelihood of the regulating authorities being able to deal only with genuine arm's-length transactions. There would seem to be no better possibility of obtaining facts and only facts.

2.58. Similar considerations prevail on the customer side of the carriers--another region beyond their boundaries. Some communications users happen to be operating in an extremely dynamic environment of rapidly progressing technology. A variety of different sources of new ideas is a vital element in enhancing Canadian prospects of remaining

in the forefront in computer applications. Many of the uses of computers require an important communications component. New entrants in data processing services have been promoting many different techniques to utilize the capabilities of computers. They have been bringing these latest techniques through the highest risk stages of innovation. If they were now to find public policy allowing financial giants from other lines of endeavour to enter into rivalry with them as well as continuing to be their suppliers, they would well question what relation Canadian public policy is attempting to establish between risk-taking and reward. Cross-subsidizing, predatory price squeezes through high communications rates and/or too low data processing charges and improper but unavoidable access by carriers to the customer lists of their rivals make a sufficient catalogue of catastrophe to keep the regulated companies out of that area, too.

2.59. As already outlined in paragraph 1.16, there is a need to regulate in some detail the relationships between telecommunications carriers and cable television companies, including the closest scrutiny of any attempts to exclude entry of independent operators by participants in either of the nationwide communications networks. There are local tax implications in some jurisdictions that depend upon the extent to which the earlier established carrier assumes control of physical cable networks. It would be desirable that the different public authorities concerned confer together and work out an agreement to ensure that tax incidence does not have the unintended effect of discriminating between communications carriers and independent cable television organizations. Technical change and public policy, not

accidental tax effects, ought to determine future developments in cable use.

2.60. There is at least some suspicion that the impact of the mixed federal-provincial jurisdiction on trans-Canada telephone rates has led to less severe downward pressure on long-distance rates than on local and single-company rates on the average. If the longer rates have as a result, even without design, moved more in the direction of the discriminatory limit of value of service and away from being cost related, that tendency poses a problem. It seems that overall rates on routes using a United States segment are and may become increasingly more favourable to customers than the rates on all Canadian routes of roughly equivalent distance. There is evidence that Canadian carriers have a policing problem to keep long distance traffic on completely Canadian routes. If building up Canadian traffic is desired, it is more efficient to have rates that support that objective. The resolution of the differentials vis-à-vis the "long" and "short" rates will require a significant federal-provincial agreement, which might lead eventually to the creation of some sort of long distance organization. If thorough examination of the specific costs convinces regulating authorities that there is a cost justification for at least part of the Canada-United States rate differential, the problem may call for a political solution.

2.61. Consistent with the argument to confine public regulation of rates and overall rate of return to those important services that tend strongly to be monopolistic because of economies of scale and at the same time also to restrict the regulated firm to regulated activities,

there needs to be an examination of cable television networks. Several companies own and control the transmission facilities as well as organizing the programme package. That is, they are in two distinct activities, each of which is monopolistic by public grant. The Canadian Radio-Television Commission (CRTC) reviews programme origin, content, scheduling, and so on. There is also an obvious need for continuing financial regulation of both activities. It is not convincing to argue that a particular message transmission system, in this case cable television, ought to be unregulated while other communications systems are regulated. A cable television system operates in its exact franchise area as a monopoly, which is granted by the CRTC in the public interest. The CRTC establishes and reviews operating conditions of the system which has received an exclusive, monopoly franchise. In such a clear monopoly case, continuing financial regulation is a necessary part of protecting the public interest. Attempting to distinguish that one type of network from the others on the basis of its being one-way transmission would be to ignore the use of the national commercial telecommunications networks for similar one-way transmission. It would also fail to recognize that cable television systems can technically be converted, at some additional cost, into two-way systems and that such conversion is likely to prove desirable. Finally, the case for continuing financial regulation rests upon the existence of monopoly power and is especially strong whenever the monopoly depends upon a grant made in the public interest. Modes of transmission used have no direct bearing on the question of regulation.

2.62. Access to the needed public rights-of-way would be an unreasonable

argument for assigning the transmission facilities and that specific business, with due compensation paid, to the major telecommunications carriers. If it is necessary in some communities, in order to avoid costly physical duplication of poles, etc., to assign stringing space, that is a simple question of establishing a regulated charge for using the same physical route. If, however, technological advances make a single cable system or other single electronic channel device clearly more economical than two communications links to individual homes and offices, there might then be a persuasive argument for one company transmitting voice, picture and data messages. Mainly on grounds of less economic disturbance, there would seem to be some preference for the present voice carriers to handle all transmission but to be denied any programme creation. There is a federal-provincial problem which is perhaps in process of being resolved by keeping provincial authorities out of broadcasting. There is of course the more complicated alternative of assigning local transmission to local companies, possibly some combination of existing cable television companies, and making existing telephone companies "long distance carriers". Regardless of the particular way in which these relationships will prove to be shaped by technical advances and regulatory decisions, monopoly conditions, whether in transmission or programme offerings, will continue to call for comprehensive regulation in the public interest. However, future prospects for further significant technological advances in this industry impose on regulatory authorities a clear obligation to cast their directives in such a fashion so as to avoid any serious innovative lags that might conceivably accompany regulation.

CHAPTER 3

REGULATORY ISSUES AND OBJECTIVES

Evaluation of Current Regulatory Practices in Canadian Telecommunications

3.1. As a general summary proposition, the breadth and intensity of administrative, judicial and legislative control or guidance exercised over the industry in Canada over the years has been minimal--both at the federal and provincial levels. Formal rate hearings or definitive technical or financial inquiries involving carrier operations have been widely spaced over time. They have also been narrowly confined mainly to a concern over the rate of return generated ex post on company-determined expansion and replacement-oriented investment programs. There has been sporadic monitoring of a carrier company's rate of return on its total capital investment which has been approved after the fact. That overall rate of return regulation of carriers has been virtually the only vehicle used for the exercise of the general mandate assigned to all levels of regulatory bodies in Canada to assure "just and reasonable" rates to users of utility services. In short, even the most active regulatory commissions in Canada have not chosen, or been pressed seriously by their legislatures or by organized sections of the public, to examine in depth utility performance criteria other than earnings on capital employed and the associated general level of the rate structure. In particular, administrative bodies have been given little if any legislative guides as to economic principles of "just and reasonable". Hence they have tended to fall back on some kind of legal determination of what is equitable as a basis of deciding

"just and reasonable".

3.2. Specifically, little attention has been paid to utilization rates of capital employed, to service standards and extensions, to the rates of introduction of new and upgrading of old services, to the rate of introduction of new technology and equipment and the scrapping of old, to least-cost efficiency or production considerations operating quite independently of earning levels which themselves are based in part on authorized final prices. Moreover, scant attention has been given to the rationale underlying rate or price relationships authorized between particular classes of service. Furthermore, virtually no consideration has been given to the appropriate limits or bounds of regulated activity or to the terms of entry and operation of new firms offering fringe competitive services.

3.3. As will be noted later, there is now considerable evidence to suggest that the broad scope of regulatory concern in the future should be considerably widened so as to include greater recognition of the larger issues enumerated above. The posture of regulatory policy adopted (both administrative and legislative) concerning these larger issues is likely to have more bearing on the long-term development of the Canadian telecommunications industry than is further more sophisticated attention to ways of determining a just and reasonable rate of return on investment or level of gross revenue generation on explicitly regulated service offerings.

3.4. In terms of past effectiveness of specific regulatory practices however, it is difficult to assess the impact on industry performance precisely. As indicated in Chapter 2 of this study, such evidence as

exists from the infrequent rate hearings of federal and provincial regulatory commissions in the past suggests generally effective control over the outside limits of any gross generation of monopoly rents or profits to the provisioners of capital--whether public or private. By long-established tradition now, it is this kind of control and surveillance that regulatory commissions throughout the country are best able to provide. But there are already increasing signs in Canada of subsidiary problems and conflicts which are not to be settled by mere regulation of profit rates.

3.5. On the other hand, a critical view and analysis of the rate structure and rate differentials for particular classes of service and equipment by regulatory bodies has not been nearly so widespread. In the case of federally regulated voice and telegraphic rates, virtually the whole initiative for detailed rate-making has rested with the principal carriers involved (the Bell system and CN-CP Telecommunications). Rate negotiations among members of the Trans-Canada Telephone System have tended to generalize carrier initiative in rate-making. The process has had to proceed within shifting and inevitably vague guidelines of adherence in theory to the elusive "value of service" concept as ratified by the earlier Board of Transport Commissioners and carried forward since, but with increasing _ad hoc_ intrusions of separate cost of service considerations. Hence the rate-averaging principle within company systems has become firmly entrenched and accepted as some kind of compromise between an incomplete commitment to rate differentials based purely on "value of service" on the one hand or on "cost of service" for specified classes of equipment or services on the other.

Leaving aside for the moment the appropriateness of either one or a mixture of the two approaches for regulatory purposes, it is nevertheless clear that up until the C.T.C. Order of 1969 on Bell Telephone, no systematic attempt was ever made to set out the extent to which rate differentials were in any way related to explicit cost differentials. That attempt is confined for the present to the broad categories of regulated and unregulated services. It is argued here that cost and revenue separations, and in more detail than the two broad categories of the 1969 Order, are long overdue. Having once decided that the determination of a "just and reasonable" rate for a service should take some account of the differential cost of providing the service, then surely users of the service and any other interested group are entitled to know the manner and extent to which cost or other considerations are to be incorporated into the rate-making process. This is the essence of being informed about the extent of cross-subsidization between classes of users which is ratified finally by the regulatory body.

3.6. Finally, while still on the subject of rate relationships, no effective control of inter-system interprovincial long-distance public message telephone tolls has existed on the part of any regulatory body in Canada because of the uncertain state of federal-provincial regulatory jurisdiction over such traffic. The rating and division of revenues applicable to traffic of this type are determined by agreement of the two systems involved in two-system transmissions, or by agreement reached within the Trans-Canada Telephone System industry consortium where more than two systems are involved in the traffic. Thus long distance inter-system telephone tolls have been subject to self regulation

by the industry essentially. Such a scheme has been workable up to the present time, but in the absence of revenue-related cost breakdowns, it is virtually impossible to assess the effectiveness of such control in terms of the public interest and that of particular classes of users. Long-distance voice and data transmission services are growing rapidly as an intermediate good, i.e., as an input of industry and commerce across the country. It is inevitable that the interests of this class of user, along with any commitment to growth of national productivity, will demand and should be entitled to fuller accountability with respect to the rate-making principles used to establish rate differentials for long-distance services versus other classes of service in Canada, and versus similar classes of service in other countries.

3.7. With respect to the effectiveness of existing regulatory practices over such other things as the type and rate of capital investment, of technical innovation and of standards of service within the industry, again such control by public regulatory bodies has been minimal and has resided largely within the separate corporate carrier systems and in the case of the telephone companies, by agreement between the systems as part of the Trans-Canada consortium. Hence regulatory practices in Canada have provided wide permissive latitude for self regulation by the industry itself in respect of the matters mentioned above. The performance of the Canadian industry under these circumstances cannot be faulted in any obvious way, when judged by comparative international standards of quality and variety of services, of capital investment as related to market coverage, and of the rate of technical advance and innovation as related to new services and the modernity of system plant

and equipment.

3.8. When judged on pure efficiency grounds however, i.e., achievement of lowest possible costs per unit of service, there seems to be reason for some reservations. Cursory indications point to substantial duplicative unused capital capacity in many sections of the trans-continental microwave trunks taking the telephone and CN-CP systems together. Such is the outgrowth of an earlier federal government policy decision authorizing the construction of a second transcontinental microwave system in the hands of CN-CP. That decision has had the effect of creating the beginnings of a duopoly structure in the mainline transmission sector of the industry. More complicated regulatory guides and practices will now be called for in the future as the potential of each system increases for the offer of generally similar services under regulated conditions. One of the most difficult problems posed in the regulation of franchised duopoly is that of exercising proper control over the possibilities of excessive and duplicative capital investment taken for the industry as a whole. The difficulty is even greater in the absence of explicit rules for market-sharing as laid out and supervised by the regulatory commission. Having in mind the inevitable moral commitments attached to precedents already set, it is difficult to find any preferred solution other than closer scrutiny in the future of the capital investment plans of both systems taken as a whole.

3.9. In summary, an overview of past regulatory (legislative and administrative) practices suggests reasonably effective self-regulation on the part of the industry which has permitted a minimum of public regulation by the C.T.C. or other regulatory boards. There has been

minimum direction from legislative or administrative bodies holding adequate ultimate powers. This arrangement has depended however on a considerable degree of self regulation by the industry itself on matters other than those bearing directly on the definition of a just and reasonable composite level of rates and rate of return on capital employed. If it has been effective, it is only because of the relatively simple nature of the system in the less complex commercial setting that prevailed until recently.

3.10. On the other hand, legislative guidance and direction as part of the overall regulatory function appears to have been sporadic and often tardy over the years. It seems not to have provided reasonably continuous guidance and policy direction to the judiciary and appropriate administrative bodies--nor to the industry through these bodies--as conditions within the industry and the country change over the years. Such is a common complaint or deficiency in most countries or legislative jurisdictions it seems. There is now evidence in Canada of a rapidly growing need to improve the liaison and long-term planning capability of governments and the telecommunications industry through the provision of machinery designed better to monitor the changing concerns of industry, legislators and administrative staffs responsible for the ongoing development of the industry in the larger public interest.

Optimum Resource Use and the Role of Public Regulation

3.11. There are two general difficulties about dealing with the whole question of optimum efficiency of resource use within a context of public regulation.

3.12. In the first place, a concept of optimization based upon the achievement of purely economic goals may often appear far too narrow to meet the needs of broader public policy goals which themselves imply a different dimension to optimization, e.g. national security objectives, environmental control objectives, social development goals, national prestige and foreign policy objectives, regional development policies. It is here that a special responsibility resides with the appropriate legislatures to spell out clearly and in good time the extent to which these broader objectives are to be pursued by a regulated industry as directed or enforced by a regulatory administrative body. Ideally as a matter of responsible government, the legislative authority should also provide the administrative body with a clear directive as to the extent to which the pursuit of broader public policy objectives is to be financed by segments of the industry users in contrast to the public treasury. The most recent example concerns the manner in which the carriers' shares of the capital investment in the domestic communications satellite system are to be recouped.

3.13. In the second place, the specification of optimum resource use itself involves several levels of generalization in terms of purely economic goals. The task of monitoring the degree to which optimization has been achieved in any category is more difficult under regulated monopoly or duopoly conditions than is the case where numerous enterprises in competition can be observed and analysed. For instance, the first level of cost optimization involves the optimum mix of productive inputs (including technology, information and managerial services) such that a variation of each input in terms of a unit of value at the margin

has the same impact on the value of output as a variation in any other input. Such would define the most efficient use of resources or inputs in a particular productive process at any scale of production which might be chosen. Optimization of resource or input use in this sense has only to do with the best technical organization of production. Only broad technical surveillance by regulators can assure that this kind of optimization is being pursued in fact.

3.14. The optimum scale or size of operations, or of total use of inputs by the enterprise, is another matter and has to do with a proper balancing of input costs not against each other, but rather against variations in revenue for every variation in the optimum package of inputs taken as a value unit of costs. If the enterprise goal is defined as profit maximization, then the optimum size or scale of output or of total input application is such that any variation in the value of (optimally mixed) total costs applied (a change in scale of operations) will generate an equal variation in total revenue. This is the well-known requirement of equating marginal revenue to marginal costs. Viewed in terms of long-run costs, this equality condition provides a guide to management as to the most appropriate scale of enterprise operations for a particular industry in terms of total profit maximization.

3.15. The two levels of optimization just discussed imply the most efficient mix and total use of input resources for the enterprise and all others like it from the point of view of producers only--but not necessarily from the standpoint of consumers. In the absence of fully competitive conditions in all respects, some enterprises may be able

to earn persistently a residual rate of return on owner inputs far in excess of that actually necessary in the absence of protected markets or natural or artificial barriers to the availability or movement of certain inputs.

3.16. For maximum efficiency of resource use combined with maximum consumer satisfaction, a third level of optimization is necessary (given the distribution amongst consumers of the various determinants of demand). This implies the offer to consumers by producers of the greatest sustainable level of output at a price which approximates the lowest attainable level of total costs per unit of output (where costs include the necessary residual returns to some inputs).

3.17. In short, all of this now implies that all existent and potential producers will be persuaded by the short and long-term forces of competition to adjust to a size of total operation yielding minimum unit costs, the latter then approximating unit marginal costs and price in the market. To the extent that all of this takes place, then optimum resource utilization can be said to co-exist with optimum consumer satisfaction.

3.18. However, the task of trying to simulate both sets of optimized results simultaneously under conditions of imperfect competition is a formidable one even under conditions of explicit public regulation. This is so for any one of a number of reasons having direct applicability to the Canadian telecommunications industry. Certain of these difficulties are now discussed separately.

3.19. In a regulated monopoly or near monopoly situation, the regulating authority has few direct reference points against which to judge the

efficiency of input combinations at any scale of operations, or the extent to which long-run average or marginal costs might be expected to vary with increased service. By definition, there are few other enterprises of sufficiently similar product, plant and equipment mix available to observe directly. Nor can one rely on the usual competitive forces of price-shaving, market encroachment and possible financial disaster to correct any inefficiencies in the cost structure if these have developed. Nor will an increase in the rate structure or in the permissive rate of return on investment necessarily provide the appropriate incentive to cost reduction. The permissive rate itself is based on costs as they appear in actuality. Moreover, any economic rent arising from a degree of protection from competitive forces or from critical public scrutiny can be realized in forms other than supra-normal profits, e.g., the many and varied forms of corporate perquisites and amenities.

3.20. In addition, as a number of authorities have noted, a positive managerial bias may exist towards excessive substitution of capital in the cost mix where a compensatory level of rates or prices tends to be judged in terms of the return generated on capital committed to the enterprise--and this could be more or less regardless of how fully or efficiently such capital is employed. A common case in trunkline communications is the extent to which management may judge it necessary to provide standby emergency or peaking capacity within the system rather than to arrange for the use of alternative facilities in another system. It may also be the case in duopoly situations or in cases of overlapping franchises or service offerings that stake-out investments may be made in installations, equipment or in the acquisition of

corporate subsidiaries in the hope of securing access by precedent to new service territory in the future.

3.21. In the absence then of self-correcting forces in the market, all such possibilities as mentioned above could well lead to cumulative lapses in the achievement of optimal cost conditions. There is therefore a special responsibility residing with any regulatory body to maintain a wide-ranging and critical surveillance of system operations; surveillance which extends well beyond an immediate concern for profit levels and an overall level of rates somehow defined as being just and reasonable. Rates must, however, also give a compensatory rate of return to the provisioners of private capital where such are present.

3.22. In short, the general level of permissive rates or prices must ultimately be related in some fashion to lowest attainable cost under regulation; and the level and mix of costs in turn are related in some fashion by management to the classes, extent and quality of services offered, to the types and modernity of plant and equipment utilized, to the extent of emergency and peaking protection built into the system, etc. If the regulatory authority is to exercise general supervision over charges and rates, it should be given a clear mandate to exercise scrutiny over broad plans and decisions affecting costs and standards of service. Moreover, there are times when costs of service may be altered substantially by legislative or departmental policy decisions taken with reference to public policy goals which are broader than those of simply maximizing efficiency of resource use in the short and medium term; e.g., duplication of trans-continental microwave systems, introduction of the satellite technology, etc. In cases of

this kind, the regulatory administrative body should be invited to inform, and should be informed by, the appropriate legislative or policy group regarding the probable impact of policy decisions on costs and user charges, and the manner in which this impact is to be handled. There is, at the moment, an apparent serious deficiency in the liaison mechanism between the legislative and executive arm of government and the administrative and quasi-judiciary bodies.

3.23. A further obstacle to regulation in pressing for optimum resource use can arise in the unlikely case of a decreasing cost industry, i.e., where the lowest level of unit costs attainable by any firm in the industry (including a monopoly firm) decreases indefinitely as the scale of operation of the enterprise increases. This is quite apart from any external economies or diseconomies arising over time which may affect the cost conditions of any and all-sized firms as the output of all firms, which is to say the industry, increases.

3.24. Within a context of long-term cost possibilities, the concept of a decreasing (unit) cost industry implies a condition of increasing returns to scale. In this unlikely practical case, long-run marginal costs would be everywhere falling and everywhere less than average costs per unit as the scale of output is increased indefinitely. Hence, any price in the market which is low enough to be equal to marginal cost could provide only a loss to the enterprise even in the long-term. Theoretically, optimum resource use in this case would call for withdrawing from production altogether, and applying the resources in some other endeavor. This is an interesting theoretical case that points to possibilities implied by decreasing unit costs which may not, however,

be realized in practice ultimately because of diminishing returns to management (an increasingly complex administrative burden, for example), etc., as the scale of operation of the enterprise increases. Moreover, the natural pressures leading to monopoly development in these circumstances would eventually permit pricing well above marginal costs. The concept of marginal cost is to be discussed in more detail later.

3.25. Of more practical concern is the case where the indivisibilities of basic technology, system design in relation to market structure, etc. are such that decreasing unit costs appear to be available to the enterprise over so wide a range of output that its upper limit may approximate for all practical purpose the entire industry demand. Such a phenomenon is not really due to increasing returns to scale properly speaking, but rather to increasing proportional returns to greater use of certain more variable inputs in combination with other lumpy or indivisible inputs, e.g., basic system design and development, basic plant and equipment used for a wide variety of services. Certain of these cost indivisibilities may bulk large in any calculation of average cost per unit of service for systems with a relatively small or a non-uniform load factor. Substantial reductions in unit costs may therefore be apparent over a very extensive range of increased volume of service-- in certain activities or territories and particularly as new and related services are absorbed more intensively within the same market area. At some stage, however, further large additions to system development will have to take place. Unit costs may rise rather sharply for a time, only to fall gradually again as other inputs and volume of output increase. The important question then is how low can the

declining average costs be expected to go in each successive stage, and as output grows, before a further large addition of indivisible inputs is required. If these minimum levels are relatively constant beyond a certain size of system, then long-run marginal costs will also be stabilized at a level approximating minimum average costs. Regulatory pricing can be guided accordingly. Moreover, if average unit cost minima appear relatively constant beyond a certain general range of output which is well below that of the ultimate market potential, then the expansion or entry of other firms as the market expands should have no particularly harmful effects on cost conditions within the enterprise in question. On the other hand, if the growth of the enterprise is constrained by new entries and by market limitations whilst unit costs are still decreasing (albeit sporadically), then all firms may have to be sustained under regulated market sharing arrangements at unit cost levels which are not the lowest attainable.

3.26. Once again then, it is evident that the ongoing regulatory authority must be prepared to analyze and monitor cost conditions characteristic of the particular industry in question, and of the constituent firms. This is not to say that detailed directives are called for, but only to emphasize that whatever the general approach adopted to rate regulation in the interests of consumers, the effectiveness of regulation in the final analysis must always be judged in terms of input and cost efficiencies, and the extent to which the benefits of these efficiencies are transferred to the public.

Discriminatory Pricing and Cross-Subsidization in Rate-Making

3.27. Any discussion of price discrimination is a complicated one since it can involve not only questions of impact on profit maximization and efficiency of resource use, but also subjective judgements concerning consumer welfare of two or more user groups, and of user versus non-user groups. Moreover, the interests of monopoly management may no longer be guided by strict motives of profit maximization where some form of profit constraint is imposed by regulation. Instead of profit maximization in the interests of owners, some have postulated instead management goals of sales or revenue maximization, or of output maximization, or of allowable expense maximization up to the point where profits are reduced to the constrained level imposed by regulation. In the absence of a regulatory restirction, the kind and degree of price discrimination practised by a regulated monopoly will depend among other things on the performance proxies which management is bent on maximizing.

3.28. Even assuming a goal of profit maximization under monopoly regulation, the results and impact of price discrimination can vary widely depending on the separable demand characteristics applicable to different but related types of service and of customer use. In the case of the single-product single-market unregulated monopoly, profit-maximizing management will seek a level of output such that marginal revenue is just equated to marginal cost. In all circumstances of marginal cost (i.e. falling, constant or rising), such a level of output will fall short of the competitive norm, or Pareto optimum use of resources, in the sense that price will exceed marginal cost at this output. In

addition, the producing monopolist will ordinarily be able to appropriate monopoly profits (that is, profits in excess of the competitive norm) except in an unusually coincidental juxtaposition of industry costs and market demand. However, a single-minded regulatory objective of excess profit elimination will not necessarily push the monopolist to the competitive optimum scale of operations except in the case of constant unit costs (everywhere equal to marginal costs). In this exceptional case excess profits are reduced to zero <u>and</u> marginal cost has been equated to the approved (uniform) price.

3.29. Where unit costs are rising however, profit elimination would imply pricing at average cost which in these circumstances must be something less than marginal cost. This implies that the monopolist would now be using excessive quantities (cost values) of community resources, i.e., input values which cannot be justified by the (uniform) prices which users of the monopoly service are asked to pay. On the other hand, in the same circumstances of rising average and marginal costs, if the regulated monopolist is pushed only to the optimum scale of output or resource use such that the authorized price is just equal to marginal cost of the service, then some excess monopoly profits still remain. Such profits cannot be eliminated (short of a lump-sum residual profits tax) via any further price-output specification without causing a non-optimal distortion in the total use of resources.

3.30. In the case of declining average and marginal cost conditions, a regulatory objective of profit elimination via reduced price specification could achieve such elimination of monopoly profits and induce some increase in output towards optimum. At the scale of output where

monopoly profits are eliminated however, authorized price will remain in excess of marginal costs. A regulated price specification which is sufficiently low to reach the marginal costs of the last increment to further production (and necessarily below average unit costs over all of production) would imply an overall loss to the monopoly (the case for a lump sum subsidy raised through a poll tax or levy on all users or the community as a whole if prices are not to be distorted throughout).

3.31. Thus even in the case of a simple or non-discriminating regulated monopoly, the imposition of a profit constraint alone (e.g. zero supra-normal profits) is not sufficient by itself to assure optimum scale of operation or of resource use on the part of the monopoly. Hence it is important to regulation to know something about the condition of returns to scale within the firm over the relevant range of expanded output--and about the influence of external economies or diseconomies on the cost structure of the monopoly firm.

3.32. Moreover, the insufficiency of a profit constraint alone in terms of optimum resource use is further aggravated if monopoly management in the face of the profit constraint turns to a variety of unsupervised adjustment objectives, the pursuit of which may cause persistent over or under production on the part of the regulated firm. Possibilities that have frequently been mentioned in the literature include non-productive expense padding by management, sales or revenue maximization with or without advertising expense, output maximization, and numerous variations or combinations of the above. Under conditions of increasing average and marginal costs, and even in the case of a simple or non-discriminating monopoly, it is possible that such management objectives

can lead to pricing below marginal costs (output beyond the Pareto optimum allocation) in the case of sales and of output maximization objectives, and to output less than this optimum in the case of amenity-ridden cost adjustment policies.

3.33. Some of these possibilities are enhanced however in the case of a multi-produce or a multi-market monopoly which practises price discrimination between users of the same service in different markets or between users of the different but often related services. If left to its own devices, and assuming a profit maximization motive, the discriminating monopolist will ordinarily price differently in the multiple markets if some part of the spectrum of point elasticities of demand in one market differs from that in the other market. For any given level of total output, total revenue to the discriminating monopoly is maximized where sales are adjusted as between the two markets such that marginal revenue in one market is just equal to marginal revenue in the other (i.e., the monopolist is selling at the margin under roughly the same conditions of elasticity in each market). The rub, however, is that the prices charged in the two markets so as to achieve total revenue maximization in this way may be quite different. For profit maximization, given the rule for revenue maximization, the discriminating monopolist will produce at a total level of output such that the equalized marginal revenue in each market is just equated to marginal cost (in the case of common or equal marginal costs in each market). Again however, as in any monopoly and by definition, marginal revenues in any and all markets will be less than demand price at any level of sales and hence the output levels will fall short of the competitive

norms. The unregulated discriminating monopolist will also fall short of the competitive "norm" optimum size or scale of output in the sense that output will not voluntarily be increased to the point where some kind of weighted average price in all markets (average revenue under discrimination) is allowed to fall to the point of equality with marginal costs. In the exceptional case of a perfectly discriminating monopoly which charges a different and lower price for every additional unit of service consumed, marginal revenue becomes virtually identical with demand price at each level of sales. That is a theoretical extreme which seems to be a practical impossibility. One of the closes approaches is the multi-block pricing often used by electric power companies. The total output will in that special case as well fall short of the competitive norm.

3.34. The general result of this kind of price and output behavior in the case of a monopoly practising price discrimination is roughly the following then: the total scale of operations or of production to all markets will be something less than the competitive norm both in total and in each market in the sense that price in each market will be something higher than marginal cost in that market. However, the monopoly price differential above marginal cost, and the monopoly short-fall in sales below the competitive norm will not be nearly so pronounced in those markets where output or sales are highly responsive to a given price change than in the less responsive markets. In the latter less elastic markets, the discriminatory monopoly price will be considerably higher than marginal cost and considerably higher than the price for the same product in the former markets where sales volume is relatively

more responsive to price changes, i.e., where demand is more elastic.

3.35. The relatively price insensitive markets are sometimes characterized by the notion of high value of service, which is taken generally to mean that a high proportion of potential users or consumers will stand ready to buy substantial quantities of the product or service more or less regardless of substantial percentage changes in price. A preponderant characteristic of this kind of aggregate demand for a product or service may arise for many reasons: the service is viewed as a comparative necessity in the budget of most consumers when judged against alternative budgetary outlays; or the service may be viewed as a virtual necessity as an intermediate input in the production of other goods; or there may be few satisfactory substitutes available from other firms or from other industries. This might be true only in certain markets or geographic regions and not in others--and it might be due either to natural characteristics of the product or to artificial or franchised monopoly restrictions on competitive substitutes. Over a wide price range, the quantities ordinarily demanded and the expenditures involved by any one consuming unit may be small relative to the income of most consuming units in the population. In short, and for a variety of reasons, the willingness of consumers in the aggregate to utilize some products or services may be noticeably less sensitive to given percentage price changes than for other products.

3.36. In markets of this kind however, where volume quantities are relatively insensitive to price changes, changes in buyer expenditures or in sales receipts of sellers will be highly responsive to price changes. Hence a 50 per cent rise in the market price of a service may

have little effect on quantity of sales in the market, but may raise the total outlay of buyers by nearly 50 per cent and, by definition, the total receipts of sellers by nearly 50 per cent. It is this latter characteristic of a relatively inelastic demand structure, and the opposite of the more elastic demand condition, that provides the driving incentive for the discriminating monopolist where possible to raise or hold up price in the less elastic demand markets. As noted earlier, prices will be adjusted to relatively lower levels in the more elastic markets, and to higher levels in the less elastic markets to the point where the last unit of sales in either market brings in the same addition to total revenue. For unconstrained profit maximization then, it is this equalized marginal or incremental addition to total revenue available from each and every market that will be equalized against the marginal cost of added output no matter where sold. The general effect of a monopoly price policy which discriminates between markets is that prices will be lower and closer to marginal cost, and output will be higher and closer to the competitive norm in the more price elastic markets; conversely, equilibrium prices will be higher and well above marginal costs, and output will be more restricted and well below the competitive norm in the less elastic or less price responsive markets.

3.37. It turns out now that these well-known results lead into a second great dilemma confronting monopoly regulation. Not only must the extent of monopoly profits in total be monitored, but also the possible differential effects on total output, total revenue and total profits if the multi-market monopoly is instructed to conform to a uniform pricing policy in all markets versus freedom to discriminate between markets.

Where a uniform pricing policy is imposed, it is clear from theory that the profit-maximizing multi-market monopolist will be manouvered into selling a higher proportion of total output at any given level of production into the less price-elastic markets, and a lower proportion into the markets of higher price elasticity than if he were permitted to discriminate in price. Since the price charged in all markets is now uniform, the monopolist must accept whatever level of sales is dictated by that same price in each market. In other words, he must accept whatever level of marginal revenue (and therefore point elasticity of demand) is associated with the particular level of sales and uniform price in each market. He is not able to jiggle the prices and sales between markets so as to reach the same point elasticities or values of marginal revenue in all markets. This being the case, the best that the non-discriminating monopolist can do is to select the uniform price and total sales so as best to average out what may turn out to be a very low or negative marginal revenue in some markets (low point elasticity of demand) with considerably higher marginal revenues in other markets (where the elasticity of demand is greater in the immediate region of the uniform price and associated level of sales). In fact then, profit maximization under the constraint of uniform pricing between markets will take place at the particular level of uniform price and associated total sales in all markets such that the weighted average of relatively high marginal revenues (high point elasticities) in some markets and relatively low or negative marginal revenues in other markets is just equal to the marginal cost of the combined output.

3.38. Given the same cost structure, it turns out in theory that for

the same level of total output in all markets combined, the maximum possible total revenue and total profit are the same or higher under price discrimination than under a uniform pricing constraint. Leaving aside a mathematical demonstration, the above result follows basically from the necessity for the monopolist under a uniform pricing constraint to sell into markets where total revenue generated from any uniform price reductions may increase only slightly or may even decrease with increased sales. Meanwhile, the uniform price will limit sales expansion in the more elastic markets at volumes which are still capable of generating high incremental additions to total revenue in these markets --high enough to balance off the low or negative additions in the less elastic markets.

3.39. In general then, the main effect of a uniform price constraint imposed on the otherwise discriminating monopolist is to induce relatively higher sales in the markets of low elasticity of demand to the point of low or negative incremental revenue additions, and relatively less sales in the markets of greater demand elasticity at a volume of sales where incremental revenue additions are comparatively high. The unfettered discriminating monopolist in contrast will jiggle prices and hence sales volume in each market separately such that the incremental additions to revenue in each and every market are about the same. To achieve this result however, final prices charged in each market may differ widely depending on the comparative elasticities of demand in the region of actual price and output combinations in the separate markets. In addition to these effects between markets, the discriminating monopolist will usually be able to gather a somewhat larger total

revenue for any given level of total sales or output than in the case of non-discrimination. He does this by means of a more thorough appropriation of consumer's surplus or welfare as monopoly profits.

3.40. Looking now at the more practical side of these results from the standpoint of regulatory implications, a number of considerations stand out. Consider first the possible effects of a zero (excess) profits constraint imposed by regulation. In the absence of a lump-sum tax mechanism levied on residual monopoly profits, the constraint will normally be imposed by holding or setting the permissive level of average prices to be charged in the rate structure to a level more closely approximating marginal and average costs. Still assuming profit maximizing behavior, the monopolist will increase output in the face of the price constraints in an attempt to achieve second-best profit optimization. But if the price constraints must be applied as uniform or non-discriminatory prices, the non-discriminating monopolist will move to an expansion of total output towards the competitive norm in a particular fashion. If on the other hand, the multi-market monopolist is permitted to develop his own rate structure adjustments, his expansion of total sales is likely to follow a different pattern.

3.41. Not only will the pattern of sales and output adjustment be different between markets, but the equilibrium level of total production at the point of (excess) profit elimination could be somewhat larger in the case of the discriminating monopolist than in the case of uniform pricing. In the latter case, a more or less uniform price can be equated to marginal costs to assure optimum resource allocation. In the discriminating case where final prices can vary between markets,

it can only be some concept of weighted average price or average revenue generated over all markets which is set off against marginal costs. This implies necessarily that prices in one or more markets must be above marginal cost, and prices in one or more other markets must be at levels below marginal cost. Moreover, if marginal costs per unit are not greatly different from average costs per unit, prices in one or more markets could conceivably reach levels below average costs. This result has numerous important ramifications for regulatory purposes. In addition, since the discriminating monopolist can generally reach a higher level of total and of average revenue at any scale of total production, it follows that the ultimate scale of production that will lead to eventual excess profit elimination under a regulatory profit constraint will be somewhat higher than in the case where uniform pricing is also imposed. Again this result holds certain ramifications to be noted later from the point of view of final regulatory objectives.

3.42. Some possible implications of the first result are the following: Where price discrimination is permitted under regulation, it is difficult for the regulatory body, for the public, for quasi-competitors and for potentially disadvantaged users in other markets to determine when, or at what point, or by how much the price in the more elastic markets might conceivably be set below costs--marginal, average, or both. Where the particular service, product, region or class of user is vulnerable to potential competition from other regulated or unregulated firms, the monopolist who is able to use price discrimination selectively holds a powerful weapon for defending existing markets or encroaching on new ones. This can be done by recouping any marginal losses sustained

in the vulnerable classes of business by raising prices at no great volume or revenue loss in the less elastic markets characterized by a higher value of service. Prices to users in these less elastic markets would now have to be set even higher above marginal or average costs. The condition of prices above long-term marginal costs now implies a misuse of inputs or resources in these markets and a clear indication that natural or franchised monopoly power is being used to exploit a relatively inelastic demand; and this remains the case whether or not the monopoly is operating under a regulated profit constraint.

3.43. It is true that the existence of a profit constraint may weaken the incentive to maximize (monopoly) profits, but it will not necessarily weaken secondary incentives of regulated enterprises. The power to extract marginal monopoly profits in the less elastic markets remains as a useful tool to absorb either non-productive or unavoidable cost increases so as to minimize adverse publicity attaching to any necessary requests for overall rate increases. It is also a useful tool for the purpose of maximizing sales volume or sales revenue as secondary management objectives within the limits of a regulated rate of return on invested capital.

3.44. Consider now the other result mentioned earlier, namely the possibility that the profit-constrained regulated monopoly using price discrimination could move to a total scale of output in excess of the competitive optimum. This would be the case where the discriminating monopolist elects to expand overall output by means of pricing below marginal cost in some markets provided that at least one price is in excess of average cost by enough to generate the allowable level of

profits. While this need not necessarily be the most efficient set of discriminatory prices from the standpoint of maximizing monopoly profits, since the monopolist is limited on profits in any event, management may be satisfied to concentrate the effects on overall growth of sales revenue or output. In this event, total monopoly output in the presence of a regulated profit constraint and an interest in sales revenue maximization could exceed the competitive equivalent of optimum size or scale in the use of community inputs.

3.45. The general effects of monopoly overproduction in this way is to concentrate the overproduction and consumer benefits of price reductions in the more elastic markets while constricting sales and reducing consumer's surplus in the less elastic markets. Pricing practices below marginal and/or average costs in the more elastic markets may also give rise to elements of destructive competition in these markets vis-à-vis actual or potential new entrants. At the same time, an overlavish use of resources will take place in such markets on a scale which cannot be supported by the prices charged in these markets. Expansion of output by reason of pricing below marginal cost is supportable only in the face of clear evidence of external economies accruing at the margin. Even in this case such economies could accrue through the expansion of output by competitors, or through monopoly expansion in other markets where prices may exceed marginal costs.

3.46. In practice, then, it is evident that single-minded regulatory concentration on monopoly profit elimination via a permissive rate of return on investment is not by itself sufficient to assure efficiency of resource use; nor to achieve any particular public policy notion as

to what may constitute equitable treatment in the redistribution of income and output benefits between various classes of utility users; nor to assure equitable treatment of actual or potential unregulated competitive suppliers. The use of a profit constraint only may itself turn monopoly management to the pursuit of other secondary objectives. The effects of these actions must also be monitored. In particular, the regulatory responsibility should provide positive guidance and supervision to the construction of the rate structure, i.e., permissive prices for various classes of user and of market demand. The allowable extent of market or customer differentiation must first of all be determined carefully, bearing in mind that demand elasticities between services, market areas or user classes may differ perceptibly for reasons having nothing to do with the franchising of a monopoly supplier, but also for artificial reasons created by the monopoly and sanctioned by regulators, e.g., exclusion of competitors, prohibitions against attachments or joint use of monopoly facilities. As a first approximation, permissive prices in particular markets should be related generally to anticipated long-term costs in those markets and particularly long-term marginal costs. As long as the emphasis is placed on longer-term costs, as it should be, then the importance of drawing fine distinctions between marginal and average costs per unit is scaled down. Estimates of marginal costs based on sustained additions to output along particular lines will then also include, as they should, some allocation of necessary system costs that must at some stage become implanted as overheads. Whilst historical cost separations and cost levels may have limited value by themselves to future pricing, they can

certainly be helpful in extrapolating probable future cost relationships.

3.47. A broader regulatory surveillance of the relationship of particular prices in the rate structure to longer-term marginal cost conditions associated with these prices is bound to assure a greater concern for the efficiency of resource use, and for equity in the effects on different classes of utility user and potential utility competitor. It provides little guidance however concerning the extent to which regulated pricing should accede to the principle of price differentiation based on differences in the value of service or elasticities of demand.

3.48. As a fully general proposition, it is difficult to make a case for the exploitation of differential demand elasticities via price discrimination. To begin with, and regardless of the consumer gains and losses resulting in different markets, the manipulation of these gains and losses by suppliers is only possible under conditions of imperfect competition. In the competitive world, rightly or wrongly, consumers are able to acquire their goods at something approaching long-run marginal costs--and this is so even in the case of a relatively inelastic aggregate demand facing the industry as a whole.

3.49. Secondly, where prices are pushed up in one market and reduced in another, it is clear that consumer welfare or consumer surplus has been reduced in the former and increased in the latter relative to the marginal relationship. But it is not possible to say whether consumers in the first market are less deserving in some sense than the other group, or that the need for the service or product on the part of individuals in the first group is in some sense inherently greater or more urgent than within another group, or indeed that the distribution

of consumer surplus and output between the two groups was fair and reasonable in the first place. As noted earlier, there are many reasons why a change in the quantity of an article or service demanded by a particular consumer unit will be more or less responsive to a change in price. In some cases, the value of service may be high simply because the utility service is used as an intermediate good in the production of other goods and services for a living. As such, the demand for, say, basic telephone service by business users may have a relatively low elasticity. Such a market would undoubtedly sustain substantial increases in rates without much fall-out of subscribers. By the same token, revenues to the telephone utility might be well sustained--or might even rise. But the costs of doing business would have risen for all subscribers. For some kinds of utility services, the effects might have serious repercussions on marginal firms, or on the international competitiveness of Canadian business for instance. In other cases, demand for particular services may appear relatively elastic simply because the item or service is more of a luxury or dispensable, or substitutable against less elaborate items. Or again, the demand for even a basic item or service may appear relatively elastic simply because of substantial income differences and ability to pay within the same class of customer. If prices are high, some users will have to cut out, or will enter the market in increasing numbers as prices come down. Who then is to say how important income, business requirements, emergency needs, product substitutability and the like are to be in rationing the product of the regulated monopoly?

3.50. To the extent that competitive costs of production are not

permitted to enter the rationing mechanism of price, then a decision as to what other elements are to enter into administered prices, and therefore the rationing of output, is surely an initiative that ought not to be left solely in the hands of a private management group. Interpersonal and inter-group transfers of consumer and producer welfare are involved to the extent that administered prices diverge from the necessary costs of all inputs required in the production of the item in question. The probable incidence and extent of such transfers where permitted, and the rationale underlying them, is surely a matter for a legislative body to spell out. Such transfers between user groups represent the extent of cross-subsidization within the system. If they are to be justified on grounds of income differences, social policy, business development or whatever else, then the legislative arm of the regulatory process is surely the place where such judgments should be articulated. This is so since a system of administered prices can readily be utilized and has the same effects as a sub-system of indirect taxation and subsidization between groups of users and between users and producers operating within the structure of administered prices. As such, discriminatory pricing based on value of service or other non-cost considerations should place an onus on legislators to justify the assumptions on which such practices are based.

Problems of Costing, Depreciation and Joint Cost Separations

3.51. Problems of costing and cost separations have received much attention in the testimony and hearings before various regulatory

commissions, and to some extent in the legal and economic literature dealing with regulatory matters. Historically, the main emphasis on costing for regulatory purposes has revolved around questions of proper total cost estimates for profit determinations, and the construction of an approved rate base or its equivalent upon which a permissive rate of return might be calculated. For this purpose, attention has been focused on the appropriate handling of depreciation or allocation of fixed costs over time, and appropriate procedures for adjusting financial requirements to meet price level changes implanted in the cost of replacing fixed assets. Little attention has been devoted to questions of joint cost allocations to various product or service lines. Thus the emphasis has been mainly on protection of the user public as a whole from the excesses of monopoly profit-taking.

3.52. But regulatory practice has been noticeably slack over the years about limiting the scope of regulated utilities to their franchised lines of activity. This has given rise to the spectre of regulated and unregulated activities being carried on increasingly within the same corporate structure, or by means of corporate affiliates which may or may not be dealing at arm's length with the parent. More recently, with the growth and diversification of business generally, the regulated firms themselves have been subject to increasing competitive pressures and encroachment. In the Canadian telecommunications industry, all of these tendencies have been noted. Many firms have acted, and many investments have been made, prior to any clearcut policy being enunciated concerning the authorized bounds of regulated activity, or of activity by a regulated firm.

3.53. In short, the result has been increasing interventions by aggrieved user and business groups. Each is concerned about price and costing practices in relation to particular services or activities of interest to the group. It is this kind of concern expressed by various separate segments of the public, more than anything else, which has and will continue to force the hand of regulation to a greater concern for separate product and service costing, and the enunciation of an objective rationale upon which particular prices are based. The regulatory process elsewhere, and now increasingly in Canada, has been virtually forced into a requirement of separate product or service costing by the frictions created as a result of increased vertical and horizontal integration on the part of the telecommunications common carriers. In the United States, for instance, elaborate cost separations between plant devoted to long-distance transmission falling under federal jurisdiction and that devoted to intra-state traffic under state regulation has added to the costing requirements. The significant point to be made here however is that the increasing emphasis on product costing and joint cost separations has not sprung from the older direct concern with profitability, but rather in connection with equity considerations, with "fair" pricing to particular user or competitive supplier groups.

3.54. While all of these developments have been proceeding as a practical matter, the more theoretical literature of finance, accounting and economics has tended to concentrate on the possible effects of pricing under imperfect competition on the efficiency of resource utilization, the distribution of consumer benefits, technical innovation, economies of scale, and so on. Accordingly, the emphasis has been on

relationships between market demand, administered prices, average unit costs, and marginal costs and revenue. Among other things, such an emphasis has suffered in its practicality because of the relatively elaborate and costly requirements for adequate market testing and cost studies. For reasons mentioned earlier, it is now the case that extensive cost studies are being required for regulatory purposes in any event. The real issue now is the form such studies should take, and the uses to which they should be put.

3.55. As matters stand at the moment, joint cost analysis submitted for regulatory purposes is carried out on a sporadic and <u>ad hoc</u> basis--and often in response to a specific challenge or intervention. As in the earlier tradition, such cost studies tend still to be rooted in historic costs and past relationships. Much time and energy are spent in a separation of direct and overhead costs, and in a further "reasonable" allocation of joint overheads to the particular classes of service or markets in question.

3.56. This approach has often been roundly criticized by economists and others who are prone to argue that the size and structure of past cost commitments may have to be recognized in current revenue requirements to satisfy utility investors, but that they are of little value for purposes of establishing guidelines to management or regulators concerning pricing for optimum use of resources in terms of product mix, total scale of operation or the distribution of consumer welfare. The argument instead is to try to provide the kind of monopoly regulation which will not only attempt to simulate the results of the perfectly competitive system in terms of profit-taking alone, but also in terms of

the pattern and size of total output (i.e., efficiency in the use of resources), and in terms of prices charged to consumers for that particular pattern and size of output (i.e., maximization of consumer benefits). As pointed out earlier, this more ambitious approach places a lot of emphasis in a variety of ways on the relationship of demand prices to marginal costs--and to a lesser extent to average costs per unit. The emphasis in this approach is on present and future cost-price relationships, and on rates of change of costs and revenues evaluated at the margin of present production.

3.57. In practical terms, the two approaches are not now so far apart as once seemed to be the case. The fact that the traditional historic cost approach to regulation has had to move already well down the road of separated product costing and joint cost separations can provide a useful base for the future. It should now be possible to recast much of the information pertaining to past cost relationships into a form that can provide useful estimates of simulated cost relationships likely to hold in the future. Nor is it the case that joint cost separations of historic sunk costs or overheads by product classes have no relevance to estimates of marginal cost which are useful for pricing and other decisions. This point leads to a further one which needs to be made with some emphasis.

3.58. Proponents of marginal costing as a guide to pricing and other management decisions may fail to make explicit the line to be drawn between long-run and short-run total costs--or in essence the extent to which short-run or cross-sectional fixed costs are considered to be variable in the longer run. It makes a great difference to any result

result if the implanted overheads of the system taken at any point in time are excluded from calculations of incremental costs attaching to this or that product or service at the margin. For instance, compensatory pricing decisions, or regulatory decisions concerning the feasibility of new entrants or private-system competition, will all be affected by the use of a particular concept of marginal cost. This choice in turn depends on a basic prior decision as to just which users in the system, or conceivably in society as a whole, should be expected ultimately to meet the costs of the physical resources and inputs which must, by the nature of current technology, become implanted at some stage as fixed overheads in the utility system.

3.59. It is argued here that the extensive exclusion of long-term variable costs (short-term fixed costs) from any concept of incremental cost has a number of serious shortcomings. It could mean, for instance, that the regulated utility would appear to provide efficiency and cost advantages in the provision of particular new or additional services over other regulated or non-regulated provisioners. The argument of a particular enterprise that it already has fixed facilities available for other purposes, and that these can readily be utilized more fully in some additional direction at low added variable cost, is not a convincing argument from the standpoint of ultimate efficiency in the use of resources. This is so because the (apparently excessive) bundle of resources later representing underutilized fixed overhead facilities was at one time purchased away from other alternative uses. The initial (marginal) opportunity cost of these resources, if the investment was justified at all, must surely be such that users of final services

produced with the aid of the fixed resources are willing to pay prices for those services over time which will justify the initial commitment to overhead--and prices by the same token which would justify further lumpy replacement of comparable overheads from time to time as technology may demand.

3.60. In short, the price for additional or new services undertaken should be such as to sustain that flow of service over the long-run if indeed the addition of that service is justified at all on anything but an explicitly terminable basis. A price or rate for a service to be offered permanently cannot therefore be said to be compensatory and optimum in the sense of drawing forth efficient resource utilization unless that price is at least sufficient to meet the long-term incremental costs of providing the service on a sustainable basis. In the case of a decreasing (unit) cost industry, this price may be slightly below the average unit cost at the margin, but only by reason of technological scale factors or external economies, and not for reasons of neglecting to include elements of fixed costs which must ultimately be renewed.

3.61. If now it is accepted that the long-run marginal cost is the relevant concept, then some separation of variable long-run joint capital and administrative costs (short-term joint overheads) becomes necessary if long-run incremental costing is to take place by product or service class. It is here that much of the by-product information from past historic cost separations can be useful. The accounting and financial data based on actual experience of the past can now be coupled with a reconciliation of engineering data concerning the

technical capability and substitutability of common plant useful in a variety of ways. From here it should be possible to construct estimates in advance of the short- and long-run marginal (or average) costs likely to be encountered in expansions or new undertakings in any direction. This is the kind of information that can prove useful for regulatory purposes in a variety of ways, e.g., evaluation of discriminatory pricing, unfair competition, new franchise extensions, new entry or private system cost comparisons.

3.62. Some mention should also be made of the practicality of seeking out marginal changes in costs and revenues rather than averaged concepts. Admittedly these distinctions can be important in theory. There is some doubt however about their quantitative importance in practice once it is recognized that the important cost concepts for most purposes are the long-run or permanent costs of providing a service, or additional amounts of a service, on a sustainable basis. This is only to say that the costs of providing or of replacing and sustaining fixed plant, research and development and administrative and other staff function overheads must be figured into any meaningful concept of incremental costs or, for that matter, average unit costs at any particular new level of output. In short, the conceptual and quantitative differences between average unit costs and incremental costs are narrowed in any event as long as one is concerned only with sustained costs and sustainable output. This is not to say that long-run marginal or average costs must appear nearly constant, or must only be gradually rising or falling with increased total scale of output. It is only to say that whatever the internally and externally influenced scale characteristics

of costs may be for the enterprise, unit average and marginal costs will not be greatly different in terms of long-run adjustments to current levels of output. Systematic adjustments to approved accounting estimates of actual long-run average costs separated by classes of service or activity should therefore yield useful first approximations to incremental costs.

3.63. To the objection that past costs and cost separations are not necessarily relevant to present decisions based on future cost expectations, one can only remark that there is nothing inviolate about past cost information, but merely that such information provides a useful base of relationships from which explicit adjustments can be made for stated purposes.

3.64. It bears repeating that rates or prices which are established on the basis of short-term marginal or average variable costs pose a number of serious implications to the pattern of consumer benefits generated by the utility operation over time. This is so to the extent that such prices fail to give full recognition to the ultimate overhead requirements (not necessarily the same as past overheads) necessary for the sustained offer of the service. For instance, the impact of overall cost-reducing technological advances might certainly alter the proportions of short-term variable to fixed costs. The extent to which the benefits of cost reduction are passed along to particular classes of user will then depend on the concepts of cost to which the administered price is related. In the case of prices related more to value of service, the benefits of cost reductions may not be passed along at all to certain classes of user, but concentrated instead on price

reductions in the more competitive markets on the fringe of regulatory protection.

3.65. Moreover, it is sometimes argued that additional new or quasi-competitive services can be offered at something approaching additional variable costs only, on the grounds that basic system design and installations are and must be available for other purposes in any event. The implicit presumption in this case however is that certain necessary fixed costs were once and must always be associated with some kind of original or basic primordial service or user; and that this class of service and user should continue to bear a disproportionate share in the ongoing sustenance and replacement of indivisible inputs (short-term fixed commitments). This is tantamount to saying that the user of a basic telephone connection should not necessarily expect to receive subsequent benefits of overall cost reductions due to increased system size and loading or new technology resulting partly from the development of new services and uses, population growth, increased commercial use and so on. Whatever the presumption made, it should be stated explicitly, and it should be made by the legislative arm of the regulatory authority and not by the industry itself.

CHAPTER 4

INDUSTRY PERFORMANCE AND REGULATORY ISSUES: REVIEW AND RECOMMENDATIONS

Industry Structure and the Bounds of Regulation

4.1. Because the public interest is a many-sided matter, the regulation of a franchised monopoly in the full public interest is a complex task even in the simplest case of one enterprise producing a homogeneous line of products or services. Such is the case because the full public interest is by no means attained automatically by simply maintaining a profit limitation on the enterprise. The public interest also calls for an assurance of adequate service; the most efficient cost mix; adequate technical innovation; equity in the treatment of customer, supplier and other business groups; and a scale of output which does not fall far long or short of optimum utilization of the communities' resources. In addition, various non-economic performance objectives may be imposed on the regulated enterprise by governments from time to time. It is the position taken here that the legislative and administrative regulatory processes in Canada should indeed concern themselves more broadly and consistently than in the past with the entire range of performance standards and its attainment rather than with profit control alone.

4.2. The structure of the Canadian telecommunications industry is by no means the simplest case of a single homogeneous monopoly which need only attract regulatory surveillance on a narrow front. Instead, by regulatory design or default in the past, several of the largest transmission companies are backward integrated into manufacturing, or forward integrated into the computer services market and the cable television

market. In addition, the two long-distance transcontinental carrier systems are gradually developing into a duopoly structure as their service offerings and capabilities move closer together. Whatever the reasons for these developments in the past, they have now greatly complicated the task of adequate public surveillance in the interests of users and of efficient and equitable industry development in the future. As noted earlier, market power of a franchised monopoly can readily be extended in various ways into all phases of the enterprise or affiliated operations--including those which may appear quite incidental to the central core of franchised activities. It is this possibility which will continue to give rise to allegations of unfair and discriminatory action by aggrieved user and competing interests.

4.3. For these reasons, vertical integration of the franchised operation, whether by separate corporate entity or not, is to be avoided wherever possible in the case of regulated monopolistic industry. It follows that any proposed extension of services or activities on the part of a regulated firm should only be permitted after careful examination of efficiency and equity factors by the regulatory authorities prior to any industry action being taken. Failure to make such a prior determination will only complicate the task of subsequent regulation.

4.4. Moreover, where the activities of a monopoly firm or its affiliates are not confined to its own protected markets, then the bounds of continuing regulatory inquiry should also be extended so as to include pricing and business practices in these auxiliary activities. If this is not done, then the possibilities of cross-subsidization between users within the extended system as a whole will often go uncontrolled. The same

could be said of various forms of predatory or discriminatory business practices; or of indirect transfers of utility revenues to affiliated firms via inter-corporate private price arrangements.

Backward Integration of Telecommunications Companies to Manufacturers

4.5. In the case of the Bell-Northern Electric relationship, the overriding balance of whatever assured market and developmental advantages there may have been in the past must surely be diminishing as time goes on. In the meantime, the inherent threat to the public interest of a relatively closed commercial relationship between the regulated and unregulated remains. If it does not seem reasonable to cut Northern loose from dominant ownership by Bell, then the present relationship will and should continue to attract regulatory attention. As part of this regulatory effort, a thorough investigation should be undertaken of the probable viability of Northern Electric to function successfully on its own in Canadian and foreign markets. In the event of a doubtful determination, it is recommended at the very least that the commercial relationship between Bell Canada and Northern be opened up selectively and in stages to other Canadian manufacturers. This should provide a useful trial period, under regulatory supervision, for new tender and contract negotiation arrangements covering supply and customized development work on the part of Bell. Northern would still be free to seek out this business or to develop more fully along other lines.

4.6. The inter-corporate supply relationships from Automatic Electric and Lenkurt Electric to British Columbia Telephone and Quebec Telephone

arise indirectly because of their ultimate common parent, General Telephone and Electronics Corporation. The research and developmental advantages to these two associated telephone companies would seem to be less than those accruing to Bell Canada in its relationship to Northern Electric. A policy of gradually opening up these telephone companies' markets to other Canadian manufacturers could be supervised at the outset in the same manner as suggested for Bell. In an investigation of this possibility, the regulatory authorities must take account of the possibility that loosening up the captive market relationship in either inter-corporate system, Bell or B.C. Telephone, might impair the viability of affiliated suppliers. Again, this should be a case for legislative determination in the overall regulation of the industry.

Forward Integration of Telecommunications Companies to Computer Services and Cable Television

4.7. In the case of the CN-CP -Computer Sciences Canada relationship, this relationship once again constitutes an intrusion of a regulated common carrier into an established customer market. As such, it represents a further serious lapse from an optimum type of regulated industry structure. The disadvantages it presents for public policy urge a searching public review of this penetration into an otherwise unregulated area of business and customer markets. A careful exploration should be undertaken of the desirability in the public interest of the sale by CN-CP of Computer Sciences Canada. If it were concluded that the relationship should be allowed to persist, it should be made perfectly clear that it is a lone exception and as such must be subject to continuing

regulatory supervision with respect to open and compensatory pricing, customer and service priorities, and business development practices. Thus the bounds of regulatory surveillance must be extended in the interests of other classes of carrier user and of rival computing service firms although there would remain a clear preference for the extension of regulation to apply solely to that one computer services firm. The extension of CN-CP Telecommunications into the field of customized data services seems difficult to justify on grounds other than general business development and the promotion of (captive) transmission business in an urgent effort to achieve greater utilization of existing mainline transmission capacity. It seems clear that the existing CN-CP capacity might well be adapted with minimum adjustment to the provision of low-speed and high-speed digital and broadband data transmission services for business users particularly--a development that should proceed successfully without any necessity for CN-CP to be directly or indirectly involved in a data service subsidiary. This will require an innovative fusing of technical developments and new market uses which could lead to substantial business development for whatever carrier is best able to meet the challenge.

4.8. The role of wired television operations in Canada's major cities has not yet stabilized fully in terms of the ultimate broadcast and closed-circuit content options available to households. For this reason, the direction of current policy prescriptions for the future should remain flexible to allow for the possibility of quite striking technological innovation in the fields of one-way selective or possibly two-way selective broadband transmission in the hands of the ultimate user.

With technological improvements and, possibly, the installation of high-capacity cable in advance, consumers should face the prospect of several options with respect to the particular set of programme packages he selects, quite conceivably at price differentials which reflect programme content and cost differentials. The direction of these developments in the future may indicate a shift in the long-run cost advantages of any particular pattern of ownership and control of cable and other outside plant.

4.9. On the basis of present modes of operation, however, there is no compelling reason to exclude private independent business groups from holding an exclusive franchise for programming, and also for owning or leasing outside plant and connections necessary for pick-up and transmission. This is subject to the provision that any such private monopolist, public carrier or otherwise, should be subject to adequate regulation of rates, charges and standards and conditions of service since the user has no alternative source of supply, including the single set of programme alternatives offered by cable. On the other hand, there can be no objection in principle to an established (nonintegrated) public transmission company providing the outside plant and connections under regulatory supervision for lease to an operator. As noted earlier in paragraph 2.18, there is an objection in principle in the case of a public carrier which is backward integrated into cable and equipment manufacturing for instance. Regulatory supervision must assure that the related cable and equipment markets become more open to independent manufacturers, as was proposed in paragraph 4.5. Whatever the preferred system of the future, it should depend on whatever arrangement is best

able to offer the widest variety of service options at low cost. It may or may not be the case that the public transmission specialists will have a natural advantage here, but this will depend largely on the nature of new attachment and equipment advances in the future. In order to safeguard the public interest in being able to realize the full potential of future technical advance, it is important to have regulation maintain current developments in as flexible a manner as possible so as to keep available some real choice.

4.10. Whatever the arrangement in the meantime, there is a strong case for overriding regulatory supervision with respect to both transmission services and programme services (original or re-broadcast) in that they are both monopolistic. This should include, with more forceful application than in the past, rentals to final customers, and charges and conditions of use and attachment in the case of existing communications carriers installing or leasing network facilities to cable television operators. Under the present circumstances of exclusive territorial franchises being granted by the CRTC, the grant of a particular monopoly operation within an urban area should carry with it an assurance of user protection with respect to rates, standards of technical service, and programme content and service. It is already clear that a substantial degree of cross-subsidization of rates from users in large urban centres to those in smaller cities is contemplated where some broadcast signals must first be picked up and relayed by microwave before going to cable. Both the principle and the degree of such cross-subsidization ought properly to be a matter for political determination in the regulatory process. Because of the monopoly grant and the prospects of cross-

subsidization, it is recommended that such comprehensive supervision be conducted by the CRTC on a continuing basis.

Price Discrimination and the Rate Structure

4.11. As noted elsewhere in this report, it is not possible to render an unequivocal theoretical prescription against elements of regulated monopoly price discrimination in every set of circumstances. This is so by reason of the ultimate impossibility of measuring the trade-off between losses in aggregate consumer welfare resulting from relatively high prices in one market, and gains in aggregate consumer welfare resulting from relatively low prices for essentially the same product or service in another market.

4.12. It is certainly possible however to underscore once more the varied and serious abuses to which price discrimination not related to costs, and widespread adherence to the value of service principle, can lead in practice. These have been enumerated elsewhere as: arbitrary deviations from the competitive norm in the distribution of prices and consumer welfare between various classes of user by means of cross-subsidization; a virtual assurance in the case of profit-regulated monopoly that some classes of service will have to be offered below any particular concept of unit cost if others are priced above that same definition of costs; access to non-compensatory (predatory) pricing practices in those classes of activity most vulnerable to competition from other regulated or unregulated existing or potential systems. Each of these main possibilities can lead to a long series of controversies

over both questions of inter-group equity and of ultimate efficiency in the use of the nation's resources.

4.13. At the same time, there may be circumstances under controlled conditions where some apparent price discrimination can be useful in efforts to achieve more uniform loading of the system, and hence lower unit costs throughout. There is also the decreasing unit cost case where marginal cost may everywhere be less than average cost, but where a revenue requirement of full cost recovery is imposed by regulation. In this case, second-best consumer welfare and resource use would be least disturbed from the optimum competitive norm by upward price adjustments from marginal cost which are proportionately greater in the less elastic markets than in those of higher demand elasticity. But these are all circumstances of considerable technical complexity in terms of cost and market data ordinarily available to management or regulators. They can hardly be thought of as justifying widespread license for the use of price discrimination under anything but the closest of regulatory supervision in the public interest.

4.14. In addition to the above circumstances however, there may also be times when the legislative arm of industry regulation may wish to authorize, impose or sanction price discrimination or cross-subsidization between classes of utility user as part of its omnipotent taxing authority. Particularly in the case of public ownership of utilities, there is frequently a noticeable disposition to use the utility rate structure as an indirect arm or extension of government policy involving a redistribution of benefits by means of indirect taxation and subsidization between users. Or in other circumstances, it may be the case

that the industry has been put to considerable private costs by government in the pursuit of certain non-commercial national objectives. If these costs are to be recovered through customer rates, the possibilities of price discrimination provide wide latitude for concentrating the incidence of cost recovery on certain classes of user.

4.15. With regard to these latter possibilities, one can only say that the initiative for such pricing decisions ought not to rest either with the industry or an appointed Commission; and that direction or sanction for any such prices should come explicitly from the legislative arm of regulation.

4.16. It is for all of these reasons then that the general recommendation here favors rate-making principles which adhere as closely as is practicable to cost of service rather than value of service considerations, and such that substantial deviations from this general philosophy should require that explicit direction and justification on the part of the legislative or policy authority be part of the overall process of industry surveillance.

Industry Performance and Objectives

4.17. Any statement of identifiable industry objectives and standards of performance must spring from a prior concensus concerning the nature of the full public interest in the Canadian telecommunications industry. The main facets of this public interest were identified earlier with respect to purely economic matters: elimination of monopoly rent or profits such that any cost advantages of natural monopoly structure

would be reflected instead as lower prices and greater outputs to the public; assurance of adequate standards and extension of service to final and intermediate users of telecommunication services; achievement of the most efficient cost mix in production; assurance of adequate technical innovation leading to cost reduction, improved service or new products or services; equity in the treatment of customer groups and supplier or competing business groups; a size of industry operation in total which is optimum in the sense of maintaining long-run viability whilst buying and selling at generally competitive prices.

4.18. Once agreed upon, these performance objectives in the public interest are sufficiently stable over time that they can be translated by legislative directive into concrete industry standards of performance. These standards can then be administered in detail by a quasi-autonomous regulatory board. The important ingredient so often lacking however is this legislative directive setting out clear expectations and terms of reference as a guide to the administrative body.

4.19. In addition to the purely economic elements of the public interest mentioned above, certain other politico-economic objectives may be defined for the industry from time to time by government. Common examples in Canada might include such things as building or maintaining an industrial capability in production or research for, say, defence purposes, science support, national prestige programmes and the like; or an objective of preponderant Canadian ownership and control might be superimposed on all of the foregoing. The pursuit of these kinds of objectives by means of public policy will not always be sufficiently stable or consistent to permit a spelling out of permanent guidelines

to an administrative board. Yet it is critically important that the decisions and directives of quasi-judicial administrative boards do not become completely estranged from the general thrust of legislative policy. It is in this area of public policy where considerable strengthening is required in the permanent machinery of liaison connecting legislative intent and stated government policy to the regulatory emphasis and practice of administrative boards.

Regulatory Framework

4.20. In the case of the first group of purely economic performance objectives, it is recommended that new legislation be brought before parliament which would encompass all aspects of federal responsibility in the field of telecommunications. This legislation should provide for the establishment of a quasi-autonomous Commission outside of the existing civil service establishment and responsible to parliament through the present Department of Communications. Or such a body could be incorporated as a special section within the present C.R.T.C. which would maintain its present jurisdiction over broadcasting. The new Telecommunications Act should set out the general powers and responsibilities of the Commission in such terms as will clearly provide a mandate to inquire into, direct and supervise the attainment of industry objectives and performance as set out above. In particular, it is important that this mandate extend and be exercised over more general performance criteria than profit limitation or a general level of rate structure designed simply to effect profit limitation, that is, it

should include powers to influence the rate and direction of capital investment in the federal carriers; to pass in advance on questions of new entrants to the industry or new activities on the part of existing firms; to influence the timing of, and preferred means of financing, the introduction of technology; to monitor business practices, commercial relations and the technical requirements for interfacing between various segments of the industry.

4.21. In addition to a specification of these broad responsibilities, the regulatory Commission should be given concrete initial guidance concerning the general nature of the rate-making principles to be followed over the long pull. It is recommended that the basic general philosophy underlying the establishment of any approved rate or rate differential be that of the cost of the service; and that the concept of cost to be applied be as near as is practicable to one of long-term marginal cost, having regard however to ongoing revenue requirements partly conditioned by cost commitments in the past. Deviations from this general principle of price uniformity except by reason of cost differentials should be permissible at the discretion of the Commission for certain general categories of reasons or class of user. The permissible classes of exception should be specified in the governing legislation or amendments thereto or in cabinet orders-in-council issued from time to time.

4.22. The directives to the Commission should require it to identify in every ruling involving an exception to a standard cost-related price, the reason and estimated extent of approved deviation from the standard applied elsewhere in the system. The purpose of the latter requirement

is not necessarily one of discouraging rate-making variations from the general standard, but rather one of providing legislators and segments of the public with a broad cumulative picture of rate incidence where elements of cross-subsidization have been authorized within the system. Moreover, the standard costs used for rate-making purposes can also be adjusted to reflect elements of any official cost subsidization which may take place from time to time by the tax-paying public as a matter of explicit government action and policy. As noted elsewhere, it is an important aspect of broad regulatory policy that the government makes clear the extent to which any industry costs resulting from national policy directives are to be met via user charges as opposed to direct government contributions.

4.23. Emphasis was laid earlier on the need for closer and more continuous liaison between the legislative aspects of industry regulation and the administrative and quasi-judicial aspects. This will continue to be particularly important in the case of the telecommunications industry in Canada because of the pace of new technology and new applications on a wide front; and because of frequent involvement of the national interest in non-commercial public policy objectives. It is recommended therefore that some kind of permanent administrative policy board be established within the civil service establishment and centred mainly around the Department of Communications. The statutory make-up of such a National Telecommunications Board should consist of the Minister as ex officio member, a full-time Director or Chairman of the Board who should be of deputy ministerial level within the Department, and several senior officials from the Department of Communications and other departments

concerned with various aspects of the industry.

4.24. The principal responsibility of this policy board in a word would be policy articulation, that is, a responsibility to see that longer-term policy issues confronting any segment of the industry are brought before and processed by parliament or by the appropriate legislative committees, or by the cabinet, or by the Minister as the case may be. It would be the principal task of the full-time Director or Chairman to anticipate such major policy issues by means of open hearings and discussion with industry representatives, and by monitoring the cumulative impact of all hearings and rulings issuing from the quasi-judicial regulatory Commission. In particular, the new Telecommunications Act would set out the general powers and responsibilities of both the regulatory Commission and the Telecommunications Board. Under this legislation, the Board would be responsible for communicating approved policy directives to the Commission from time to time with respect to the broader aspects of regulatory policy, for example, financing of non-commercial national objectives, matters concerning foreign ownership and control, alterations in basic rate-making principles or exceptions, alterations to the bounds of regulation, changes resulting from federal-provincial jurisdictional agreements, shared research and development programmes. A critical part of the Board's responsibility would be to initiate examination of industry problems so as to assure that policy decisions will keep pace with industry developments.

4.25. The Chairman or Director of the National Telecommunications Board should be entitled to sit as a non-voting member of the regulatory

Commission so as to have access to all written and oral submissions to the Commission. The National Telecommunications Board should itself be provisioned with adequate research staff of its own as a section of the Department of Communications. This staff should have access to and be co-ordinated with the staff activities of the regulatory Commission. All directives issuing from parliament, the cabinet or the Minister to the regulatory Commission from time to time should be carried in the Canada Gazette as public notice.

4.26. The policy Board should have the further responsibility to initiate informal hearings for the purpose of consulting with industry representatives or other parties, and to call similar hearings in response to a request from any segment of the industry at any time on reasonable notice. Notice of such deliberations should be circulated to the industry and others in advance, and should take the form of open and informal meetings.

Problems of Divided Regulatory Jurisdictions

4.27. As noted earlier, the manner and particularly the extent of regulatory activity embracing the telephone industry varies considerably across the country in the case of provincially incorporated or government owned telephone companies. For the most part however, overt regulatory activity has been slight to non-existent on the part of provincial regulatory commissions. This has been due to a preponderance of direct or indirect governmental control in the prairie provinces, and to extensive Bell affiliation in Quebec and the Atlantic provinces.

As a matter of practice then, the larger provincial and municipal carriers have been free to raise their own revenues according to individual management precepts and whatever guidance they wish to adopt from experience in other systems as members of the Trans-Canada Telephone System consortium.

4.28. The major source of interprovincial and inter-system friction to date has concerned the establishment of long-distance rates and revenue-sharing formulae applicable to such traffic. Even here the system members of the consortium have so far managed to reach amicable settlements voluntarily and without the active intrusion of the C.T.C. into the field of long-distance rates. This has had the effect of preventing a head-on collision of governments or their respective regulatory bodies as has happened so frequently, for instance, in the experience of the U.S.A. But there are now signs that this state of affairs may come under increasing pressure in the future.

4.29. In the first place, previously unregulated dedicated line services may soon come under regulation in the case of the federal carriers. A good deal of this traffic has involved data transmission by both of the transcontinental systems, and much of it involves service offerings of an essentially comparable and competitive kind. Moreover, the volume of long-distance data traffic in the aggregate is increasing rapidly. In the competition for subscribers in the future, neither system will be willing to submit to rates which will place it at a serious disadvantage. On the other hand, pressures will continue to mount on the part of the computer services industry and its customers for lower rates and more divisible time- and channel-sharing services.

The large scale use of data manipulation and transmission as an important intermediate input to Canadian business will continue to grow rapidly. Rates and charges for service will undoubtedly come under increasing scrutiny by commercial users in relation to charges for similar service in the U.S. and elsewhere, or to U.S. connections. Already there is evidence to indicate an increasing centralization of data processing accounts of Canadian subsidiaries of U.S. corporations at computing centres located in the U.S. An examination should be undertaken in order to determine the extent to which this trend is a result of rate and service differentials or of other parent company policies. Finally, the development of large high-capacity computing centres in the large urban locations has led to a relatively high proportion of long-distance interprovincial traffic in data transmission.

4.30. In the face of all these developments, it is unlikely that the past low-key laissez-faire regulation of long-distance rates can continue in the future. Certainly long-distance rates in relation to costs of the service should be subject to more detailed analysis than has ever taken place in the past. If lower rates should be justified as a result of closer examination by a federal authority, this will imply less lucrative returns on such business passing into, out of or through the provincially regulated carriers. It is at this point that provincial regulatory jurisdictions may wish to contest the relationship of long-distance to local exchange rates from the standpoint of total impact on ratepayers as a whole within the province. Especially in the less commercialized provinces, the trans-provincial day-time long-distance revenues generated principally by business users provide a useful means

of holding down rural and local exchange rates. At some stage however, the extent of current price discrimination practised between residential and business users (in this case interprovincial business users) will have to be reckoned with.

4.31. Matters would be simplified of course if it were perfectly clear that the federal authorities have jurisdiction over any telecommunications traffic crossing provincial boundaries. Because this is not clear, and because it may be inauspicious to test the matter in the courts unless seriously pressed to do so, it may be preferable for the federal government to take the initiative in an exploration of a voluntary arrangement. It might be too much to hope for a voluntary disposition in favour of exclusive federal jurisdiction over inter-provincial long-distance traffic. Failing this, it might be possible to exercise joint responsibility once agreement has been reached on a proper formula for long-distance rate-making. In this event, the federal authority might well offer to assume the costs of a definitive cost and rate analysis from which a formula or set of guiding principles might be devised for later discussion and agreement. Undoubtedly such discussions might well involve representatives of the various public utilities commissions, as well as representatives of governments. All of these initial discussions and technical work might well serve as a later basis for wider joint agreement on reasonably uniform and consistent approaches to rate-making and regulatory matters covering all carriers across the country.

4.32. Failing agreement on specific principles or a formula which spells out rate changes over time in response to certain other changes,

it may be necessary, whenever interprovincial rates are up for examination, for a member of each provincial board to sit jointly with the counterpart federal board in the hope that some determination can be agreed upon on each occasion.

Industry Growth and Diversification and Regulatory Practices

4.33. An overview of the general regulatory prescription offered here for the Canadian telecommunications industry as a whole contains the following features: The broad objective of industry regulation and surveillance should not be confined solely to detailed practices within the directly regulated monopoly segments of the industry. It should not ignore the implications to industry development of such questions as foreign ownership of elements of the industry or of business users of the industry, foreign competition in vulnerable segments of the industry, and government supported developmental projects. It should extend as well to broad surveillance of the nature of commercial and technical relations between the monopoly carrier segments and the competitive supply, service and user segments of the industry. The regulatory process, through the cumulative impact of its directives and decisions, should seek to promote the kinds of relations between the protected and competitive segments which appear to be best suited to the orderly growth and development of a diversified industry structure capable of competing at home and abroad.

4.34. To achieve this requires regulatory machinery with a proper intake capacity for legislative and administrative policy inputs as

well as the technical inputs necessary for ongoing rate regulation in the monopoly segments. It also implies adequate provision for the airing of industry complaints and points of view in open but informal circumstances, and an assurance that the force of public policy determinations in the end will take the form of open and explicit policy directives to the responsible regulatory Commission for implementation.

4.35. The bounds of licensed monopoly activities requiring direct rate and financial regulation should be as narrowly confined as is clearly consistent with any cost advantages accruing to a monopolized operation. At the same time, the nature of the commercial relations between the directly regulated monopoly operation and any unregulated segments of the industry must be broadly supervised in the interests of both equity and efficiency in all parts of the industry. Equity questions in particular have received in the past too little specific attention in the regulatory process. Because of this shortcoming, there has been considerable emphasis in this report on the need for broader surveillance of industry affairs. The technical standards and conditions of interface with or attachment to common carrier facilities should be no more restrictive than is absolutely necessary to avoid degrading of service. In short, broad surveillance is required to assure that the monopoly franchise is not being used to inhibit unduly the innovative development of new equipment and applications by non-carrier components of the industry.

4.36. Superimposed on this mix of direct regulation and broad supervision is the overriding requirement which is best suited to the protection of the public interest, namely, an openness and explicitness about all aspects of commercial relations and of legislative and administrative regulatory directives throughout the whole of the industry.

TELECOMMISSION

Study 2(b)(i)

Communications in Canada: A Statistical Summary

The Department of Communications

UNIVERSITY OF TORONTO
INSTITUTE FOR THE QUANTITATIVE ANALYSIS
OF SOCIAL AND ECONOMIC POLICY

150 St. George Street/Toronto 5/Canada/928-4854

STUDY 2 (b) (i)

COMMUNICATIONS IN CANADA

A STATISTICAL SUMMARY

September, 1970

Available by mail from Information Canada, Ottawa,
and at the following Information Canada bookshops:

HALIFAX
1735 Barrington Street

MONTREAL
1182 St. Catherine Street West

OTTAWA
171 Slater Street

TORONTO
221 Yonge Street

WINNIPEG
393 Portage Avenue

VANCOUVER
657 Granville Street

or through your bookseller

Price: $4.50 Catalogue No. Co41-1/2B-1

Price subject to change without notice

Information Canada
Ottawa, 1971

COMMUNICATIONS IN CANADA: A STATISTICAL SUMMARY

CONTENTS

Chapter III. Demand

Chapter IV. Production

Chapter V. Investment

Chapter VI. Broadcast

Chapter VII. Manufacturing

Chapter VIII. Projections

COMMUNICATIONS IN CANADA

A STATISTICAL SUMMARY

Preface

The aim of this study is to provide a statistical summary, attempting to set in perspective the recent evolution of the telecommunications sector in Canada, viewed from the outside, and at an aggregate level.

In this effort we have enjoyed substantial cooperation from participants in the industry - particularly Bell Canada, Canadian National Telecommunications, and Canadian Pacific Telecommunications - and we wish to acknowledge with thanks the assistance they have provided. It is noteworthy that this cooperation has been both prompt and extensive, providing us some necessary data which would otherwise be unavailable. There has been no attempt to influence or re-orient our analyses, even when some of those with extensive experience in the industry might have felt impatient with our apparently naive attack upon problems with which they have grappled (at a more detailed level) for a substantially longer time. We are grateful both for their help and for their patience.

In this connection it should be emphasized that our goal- our mandate as we interpret it - is to achieve a perspective from outside the industry, not a detailed understanding of the technology or of the industry

at the level of the individual firm. Detailed market analysis or detailed investigation of day-to-day optimization in the operation of existing telecommunications systems are taken to be outside our terms of reference. We hope that by looking at the industry as a whole we may highlight some trends and developments which may not be apparent to individuals concerned with the fortunes and challenges of particular firms. Even at that, much of what we say here is neither new nor startling to the participants in the industry or to informed observers, but the trends we discuss are documented in a consistent way and are reasonably comprehensive in their coverage. This work, together with the accompanying data bank, should thus provide useful statistical background to more specific and policy-oriented analyses to be undertaken by the Department of Communications.

This study is one of two companion studies commissioned by the Department of Communications. We have acted in consultation with Professor Leo Bakony of the University of Victoria in dividing the labour for this analysis, and in establishing a common set of assumptions regarding the macro-economic environment in which the projections must take place. We have agreed with Professor Bakony to use the general framework established by the Economic Council of Canada in its macro-economic projections. From there this study has undertaken to look at industrial and commercial demand for telecommunications, along with the overall production and investment relationships, and projections of these, for the sector as a whole.

Professor Bakony is submitting a separate report, taking responsibility for more detailed analysis of household demand for telecommunications services.

This study has been the work of several participants. Without going into detail, it is perhaps appropriate to indicate that general responsibility for initial drafts of Chapters II and V was undertaken by Professor T.H. Liu, for Chapters IV and VII by Professor L. Waverman, and for Chapter VI and the telegraph portions of Chapter III by Professor M.D.G. Copeland. All three contributed to the projections set out in Chapter VIII. Professor L.D. Taylor took responsibility for the bulk of Chapter III and, along with Professor T.A. Wilson, provided invaluable consultation and advice on all aspects of the report. Overall responsibility for the study and for the final version of the report must be accepted by Professor A.R. Dobell on behalf of this Institute.

A.R.D.

Summary

Quantitative analysis of individual sectors of an economy, as opposed to the estimation of aggregate relations for a model of the economy as a whole, is important in the analysis of economic policy, particularly to agencies - such as the Department of Communications - charged with responsibility for regulation of activities in specific sectors. The present project does not attempt so ambitious an undertaking as a complete model of the telecommunications sector, but this goal has nevertheless guided our efforts. A conceptual framework suitable for construction of such a quantitative model of the industry is outlined in Chapter I of this report. This summary brings together the results of the succeeding chapters, interpreted in the context of that framework.

In bare outline, our analytical superstructure can be described as follows:

1. With time series on revenue, prices, and income, we have estimated relationships describing the demand for telecommunications services (telephone and telegraph) and various of its components. We also have done the same for broadcasting services, taking into account the fact that the nature of the demand for broadcasting is very different from - much less direct than - the demand for other two-way telecommunications services. We have assumed that the output observed is

in fact equal to demand, which is tantamount to assuming that scarce capacity has not rationed supply over the period we study.

2. Taking output as given - employing the same revenue and price series - we have estimated production functions for all telecommunications services except broadcasting. Our argument has been that the fundamental theoretical requirement necessary to justify the analysis - the assumption of technological efficiency in production - is not in fact called into question by the well-known Averch-Johnson effect,[1] because the Averch-Johnson discussion does not apply to a production function based on fixed stocks of durable capital goods. (The discussion is relevant not to the production decision, in other words, but to the investment decision.) In addition to production functions, we have also estimated input requirements functions for telecommunications services, and crude input requirements functions for broadcasting. We have found that a smooth Cobb-Douglas production function yields excellent results for the telephone sector, but not for the smaller telegraph sector.

---

1. The literature initiated by Averch and Johnson suggests that since "gold-plating" or overly capital-intensive operations is not penalized by rate-base rate of return regulation, such undue capital accumulation will be generally observed in industries so regulated.

3. Employing the same capital measures and capital goods deflators where possible, and employing industry survival curves to construct a net stock by a perpetual-inventory method where necessary, we have estimated investment functions for telecommunications services. It is at this point that the Averch-Johnson idea should be taken into account, and indeed our results confirm that conventional maximizing decisions reflecting market cost-of-capital concepts are not applicable to this sector. Thus the results of our investment chapter are logically consistent with the existence of a Cobb-Douglas pseudo-production function when the fact of the regulatory process is taken into account. Investment behaviour of the broadcasting industry has again been analyzed separately.
4. Adding the investment outlays for telecommunications services to those for broadcasting, and adjusting for direct import leakages, we obtain the demand of the telecommunications sector for communications equipment to be purchased on capital account. Adding in the input-output table estimates of demand for communications equipment as intermediate goods, we arrive at a total demand for communications equipment. This in turn may be distributed back to the suppliers to the equipment manufacturing sector.

With this distribution, we complete one phase of an analysis of the telecommunications sector and its links with the rest of the Canadian economy, for we have arrived at estimates of the impact of the sector on gross domestic product, on factor markets, and on inter-industry flows. Further analysis remains. One should go on to look at wage formation and the determination of capital costs, so as to "price out" the input requirements functions and thus obtain estimates of costs of production. Together with output prices established either by regulation or in markets for telecommunications services, these costs will determine dividends and financial capital requirements. These forces in turn determine equity valuation, the capability to attract capital, and the stance of the companies before their regulatory agencies.

Unfortunately, this study cannot venture into any analysis of these further issues. Already our work has proceeded far beyond what was envisaged in the terms of reference for this study, and extension of the analysis into the difficult problem areas just listed must entail a much longer-range study. While we have no doubt that such an analysis would be useful, it must be left to another occasion.

The major conclusions of our analysis are as follows:

1. The demand for telecommunications services is characterized by strong inertia in the short run. This is true for

broadcasting, as well as for telephone and telegraph and cable.

2. In the long run, the demand for telecommunications services is elastic with respect to income. Again, this is true for each sector taken individually.
3. For the most part, the demand for telecommunications services is insensitive to the relative prices of the services. For telephone, the demand for local service of either businesses or households is independent of price, as is also the demand for long-distance service on the part of businesses. Only in the demand for long-distance service by households is there a sensitivity to the relative price, and this appears to be quite substantial. (In interpreting this result, however, it must be kept in mind that whether long-distance rates continue to fall in the future depends upon the pace of technological change and subsequent decisions of regulatory authorities.)
4. The demand for telephone services appears to be homogeneous across regions of the country.
5. On the production side, a Cobb-Douglas production function yields quite plausible results in describing the technology of the telephone industry in general, and of Bell Canada in

particular. The results for Bell Canada suggest that this firm enjoyed mild economies of scale over the period 1952 to 1967. This finding is corroborated to some extent by input requirements functions which exhibit increasing returns to scale in the utilization of inputs. In interpreting these results, however, it must be noted that our methodology does not enable us to separate true economies of scale from a spreading-of-overhead resulting from a higher utilization of a given plant. Even if true economies of scale exist, lack of pertinent data keeps us from saying where in the collecting-switching-trunking sequence these economies exist.

6. Investment in the telecommunications industry is best described by a distributed-lag accelerator model. This may seem to be at odds with the finding that a smooth-substitution Cobb-Douglas production function describes the technology of the industry. However, these results can be reconciled when the effect of regulation is taken into account. Regulation affects the investment decision, not the production decision. Once the capital stock is in place, the industry still has an incentive to produce a given output in the most efficient manner possible, and the transformation of variable labour and fixed capital inputs into output can be approximately described by a smooth production function.

7. As regards the future course of the telecommunications industry, the demand for its output is projected to grow faster than the economy overall, which means that telecommunications will put even stronger demands in the future than it has in the past on the nation's capital markets in order to finance the needed expansion in plant and equipment. Detailed projections of revenues, labour and capital inputs, and investment outlays are set out in Chapter VIII.

INTRODUCTION AND SUMMARY

1. Terms of Reference

In a memorandum of agreement dated September 30, 1969, between Her Majesty the Queen in Right of Canada and The Board of Governors of the University of Toronto, the Institute for Quantitative Analysis of Social and Economic Policy of the University of Toronto undertook to transmit to the Department of Communications an economic and statistical analysis of the telecommunications industry in Canada.

The terms of reference of the agreement require that the study include:

1. A definition of the telecommunications industry, with an identification of the major participants and a discussion of any aspects of the industry structure relevant to later statistical analysis.
2. An analysis of available data for the industry in order to compare scales of operation in the sector with economy totals, and to study purchases from and sales to other sectors of the Canadian economy or other countries.
3. An analysis and projection of demand, production,and investment for various components of the industry.
4. A review of anticipated technological developments and an investigation of possible impacts upon the industry.

A subsequent contract involving the same parties called for an extension of this study to include relevant aspects of radio and television broadcasting and telecommunications manufacturing. Results under both contracts are included in this report.

Communications in Canada: A Statistical Summary

2. General Methodology

The research efforts underlying this report have fallen generally into three clearly-defined areas, as indicated in the summary of our terms of reference, and as dictated by overall research requirements:

1. Definition of the telecommunications industry and assembly of historical data;
2. Analysis of the historical data to provide statistical estimates of behavioural and technological relationships which characterize the industry;
3. Use of these relationships in conjunction with assumptions about the future deployment of telecommunications technology and the growth of the economy to forecast activity levels of the industry in 1980.

a) Definition of the Industry

The definition of the telecommunications industry employed in this study has evolved from analysis of the wide variety of communications services provided by the organizations involved in this sector, and of the industries which manufacture telecommunications equipment. (For the purposes of this report all aspects of satellite communications have been excluded from the definition of the telecommunications industry.) The specific activities are examined later in this report, but briefly, these are:

1. telephone (transmission of voice messages, both local and toll)
2. telegraph and cable (transmission of written records)
3. broadcasting (radio and television)

4. other telecommunications services offered by the telephone and telegraph companies such as:
   a) private wire service - i.e. dedicated lines allowing the user to employ a line from one point to another for voice, data, or remote program transmission. (It should be noted that the latter service is not a broadcast.)
   b) switched subscriber service (i.e. services using a common trunk network but which involve switching).
5. Manufacture of telecommunications equipment.

Chapter II describes the data collected on the activities of the telecommunications sector so defined.

Except for an occasional note in passing in Chapters II and III, only the marketed services of companies engaged in these activities have been examined. Excluded from the analysis, therefore, is the communications output which a number of companies, such as Ontario Hydro, are able to provide to themselves as by-product of their primary activity.

b) Data assembly

Data assembly is necessarily the point of departure in any empirical investigation, and this was the first order of business. Data have been obtained from a number of sources, both public and private, and, in keeping with our general terms of reference, additional information has been obtained from informal discussions with representatives of the industry. Since large

segments of the telecommunications industry are regulated in the public interest, substantial amounts of data pertaining to the industry are already in the public domain, appearing in regular publications of the Dominion Bureau of Statistics. Needless to say, these publications have been one of our two major sources of information. A second major source has been a number of individual companies, who have made available to us certain unpublished data, much of it on a confidential basis. Descriptions of all data used in the study, together with sources, are given in Chapter II. A data tape recording the individual data series, together with a small computer program for manipulation of these data, was turned over to the Department of Communications; save for confidential information, these data are available upon request to the Institute for Policy Analysis.

c) Analysis

Although the historical data are of considerable interest in their own right, and descriptive of trends in the industry and economy as a whole, their primary function in this study has been as input into the estimation of statistical relationships, both behavioural and technological, which characterize the telecommunications industry as an economic entity. In developing these relationships, our efforts have been conditioned from the start by a conceptual model which imbeds the telecommunications sector in the total economy. This model can be described with the aid of the flow chart given in Diagram 1.

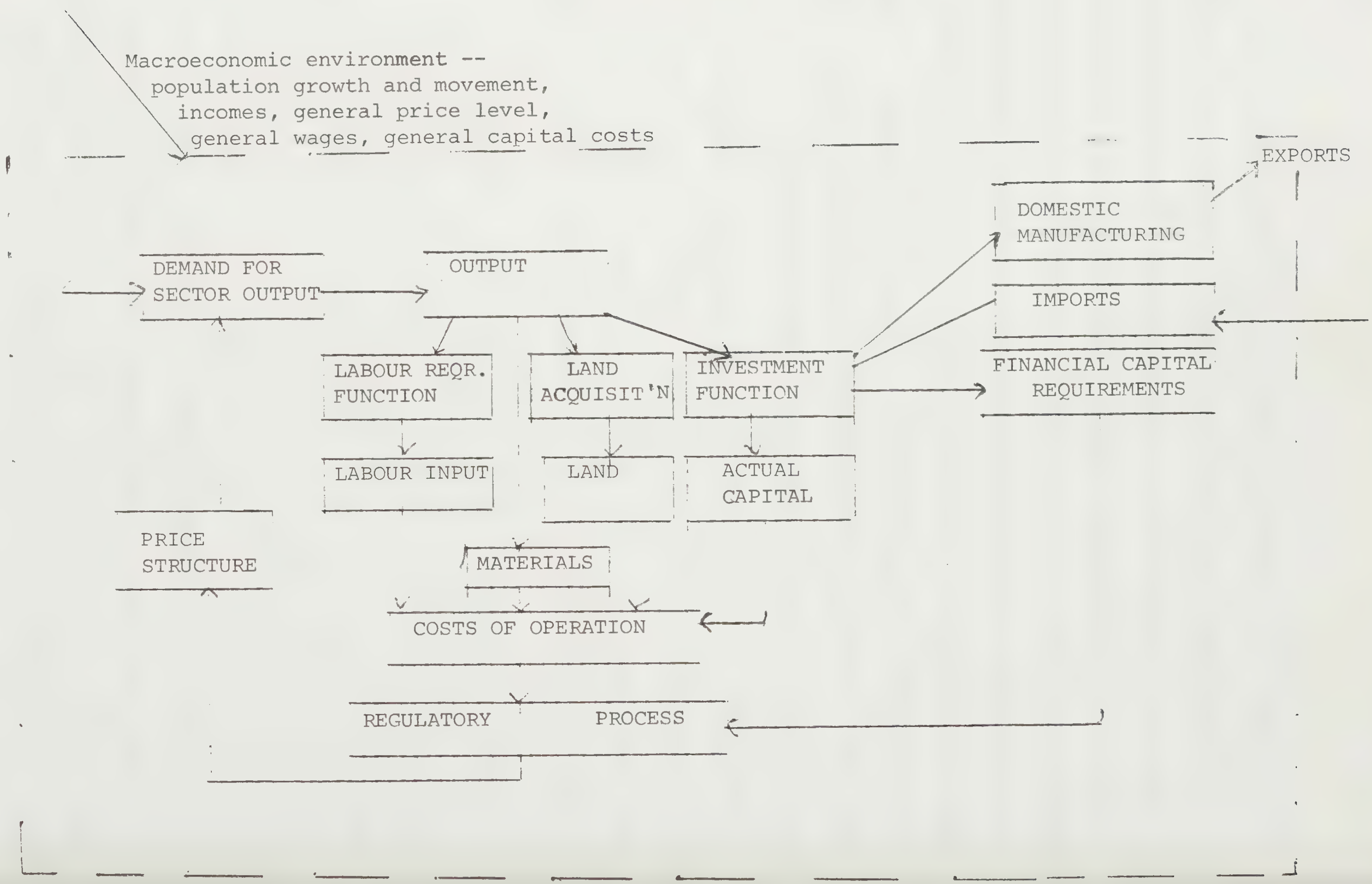
We begin in the upper left hand corner of the chart with the demand for telecommunications services on the part of business, households, and the government. We take demand to be dependent on the general macroeconomic environment as reflected in population growth and movement, the level of national income, and the general level of prices, and also upon the prices of communications services. The latter consideration is sometimes felt to be of little importance in determining demand, but as will be seen in the sequel, our results suggest otherwise. Because of its obvious crucial importance, isolation of the determinants of demand has occupied much of our attention, and forms the subject matter of Chapter III.

After the level of output has been determined, the problem is to determine the amounts of inputs - labour, capital and intermediate goods or raw materials -required to produce this output. To do this, our approach has been to estimate functions which describe statistically the amounts of labour, capital, and other inputs that are required for each unit of output. This task occupies Chapter IV. In estimating these functions, allowance has been made, in one form or another, for the technological progress which has occurred at a rapid rate in the telecommunications industry during the post-way period. Engineers may shudder at the procedures we have had to follow, but we hope that they will bear with us.

The next set of arrows in Diagram 1 flow from the input requirements to the costs of operation, for once the input requirements are determined, these combine with prevailing wage rates, rents on land, prices of materials and costs of capital services - all of which we assume to be determined independently of the level of output - to determine the costs of operation. After indirect taxes are taken into account, profits on operations are then deter-

Diagram 1

Econometric Model Framework for Telecommunications Sector



mined as the difference between revenues and costs. If these are less (calculated, after profits taxes, as a percentage of a rate base) than the maximum allowed by the regulatory body, the industry will probably move to increase its rate of return by seeking permission to raise the prices of some telecommunications services.

Our assumption with regard to investment is that the industry's current investment is determined primarily by its expected future capital stock requirements. The industry invests now in order that additional capacity be in place when it is needed. An investigation into the patterns of investment outlays is described in Chapter V.

This new capital must be manufactured - thus the arrows feeding into domestic manufacturing and imports, representing the content of Chapter VII - and it must also be financed. How it is financed, in turn, has implications for regulation and pricing. The circle is completed by the feedback of pricing on the demand for the industry's output.

All the above discussion refers to the services of the telephone, telegraph, and cable companies, services which involve two-way transmission of information, or at least involve specific recipients of the service. Specific charges can therefore be levied on the user. A similar analysis is required for radio and TV broadcasting, one-way transmissions intended for communication to an audience of many individuals, none of whom are individually identified at any one time. For this reason our analysis, though it parallels that outlined above, is conducted separately for the broadcasting component of the sector, and is set out in Chapter VI.

The scheme just described is obviously an idealization, but it nevertheless captures what in our opinion are some essential institutional and behavioural

aspects of the industry. These include the following:

1. Large segments of the industry are regulated in the public interest;
2. The industry estimates the amount of output that will be required for some period in the future, and then sets about to provide this output in the most efficient way possible;
3. Anticipated demand determines the size of the capital stock required, and this in turn determines the amount of current investment;
4. Pricing under regulatory constraint is geared primarily to ensuring that the industry can marshall the financial resources required to finance necessary capital expansion.

In putting the above model into execution, our analyses have necessarily been tempered by practical considerations, especially as regards data limitations and the time available to us. The time constraint has forced us to be less ambitious than we would have liked, and the lack of data has restricted our application of the full model outlined in Diagram 1 to the telephone industry in general, and (in some relationships) to the operations of Bell Canada in particular. For the telegraph and cable industry, it has been possible to analyze only the conditions of demand and the determinants of investment, and for broadcasting only the conditions of demand, with brief reference to input requirements and investment behaviour. Even within the telephone industry, data limitations have severely hampered our ability to take into account technological change.

Despite these limitations, we have undertaken some tentative projections, based on the conceptual framework described above and on estimated statistical relationships consistent with that framework. These projections are set out and discussed in Chapter VIII.

3. The Telecommunications Industry at a Glance

Canada can be proud of her telecommunications industry. From the world's most northerly telephone exchange 600 miles inside the Arctic Circle at Resolute Bay, to Windsor in the South, St. John's in the East, and Annette Island in the West, Canada's communications network is as extensive as it is modern, and puts some form of rapid communication within reach of virtually every resident of the country. The network is serviced by more than 2,000 telephone companies acting in concert to provide continental service, and by two railway companies, national in scope, acting jointly to provide continental telegraph service, while overseas messages are relayed by the Canadian Overseas Telecommunications Corporation. Messages are transmitted by means of microwave, tropospheric scatterwave systems, land lines, cable, and high frequency radio bands. The past few years have seen many advances in the field of telecommunications, facilitatating speedier transmission of both man-to-man and machine-to-machine communications.

a) Ownership Structure of the Telecommunications Industry

Canada's telecommunications common carriers are largely Canadian-owned. For example, American Telephone and Telegraph holds only approximately 2% of the equity in Bell Canada, theremainder of the equity being widely held by Canadian residents. However, Anglo-Canadian, a subsidiary of General Telephone

and Electronics (GT & E) in the U.S., has majority control of British Columbia Telephone Company, and Quebec Telephone is also associated with GT & E. Of the Trans-Canada Telephone System members, Bell owns approximately 50% of the New Brunswick Telephone Company, Ltd., 99.6% of Newfoundland Telephone Company, and 52% of Maritime Telegraph and Telephone (but only 5% of its voting shares). Maritime Telegraph and Telephone in turn controls Island Telephone Company (a telephone company serving Prince Edward Island, but not a TCTS member).

The systems of the cities of Edmonton and Thunder Bay are municipally owned. The Manitoba Telephone System, Saskatchewan Government Telephones, and Alberta Government Telephones are provincially owned, while the systems in Nova Scotia, New Brunswick and Prince Edward Island are privately owned with provincial charters. British Columbia Telephone Company and Bell Canada are investor-owned with federal charters.

Bell Canada has an agreement with the American Telephone and Telegraph Comapny whereby for an annual fee the latter company provides advice and assistance on technical and operating matters. Nine major telephone organizations have similar agreements with Bell; British Columbia Telephone Company has a corresponding agreement with General Telephone and Electronics Corporation.

With respect to equipment manufacturers and suppliers, Bell Canada's wholly owned subsidiary, Northern Electric,has an agreement with Bell requiring Northern to manufacture materials upon Bell's request, and, like Bell Canada and A.T. & T., Northern Electric and Western Electric (an A.T. & T. subsidiary) have

a reciprocal agreement regarding information relating to the development and manufacture of telephone equipment. Likewise, British Columbia Telephone Company has an ownership link with a manufacturing enterprise (Automatic Electric). Canadian Telephone and Supplies, Ltd. and Dominion Directory Company Ltd. are two wholly-owned subsidiaries of Anglo-Canadian Telephone Company. General Telephone and Electronics International Inc. (a subsidiary of General Telephone and Electronics Corporation) owns all the outstanding shares in Sylvania Electric (Canada) ltd., and this latter company in turn owns all the outstanding shares of Lenkurt Electric Company of Canada, Ltd. Thus, although the major common carriers are Canadian, many of the peripheral operations appear to fall within large U.S. systems.

As we mentioned earlier, CN Telecommunications (a division of a crown corporation), CP Telecommunications (a division of an investor-owned company), and the Trans-Canada Telephone System each own and operate microwave systems. There are also private microwave systems in operation in Canada, some of which are leased by CBC and the CTV Television Network Ltd., and some of which are operated by large organizations such as Quebec Hydro for their own control and communications requirements.

The CBC (The Canadian Broadcasting Corporation) is a federal crown corporation and as such is responsible to Parliament, reporting through the Secretary of State as designated in the Broadcasting Act. On March 1, 1969, there were 267 AM, 70 FM and 239 TV stations privately owned. Approximately 95% of these private stations are members of the Canadian Association of Broadcasters.

b) Composition of Telecommunications Services

Telephones

The growing range of services offered by the telephone industry is indicative of the trend in Canadian telecommunications generally . Services now available to individuals and businesses include the direct dialing of long-distance calls and rapid connection to overseas telephones as well as high speed data transmission, facsimile transmission, and instant access to permanent "hot-line" connections.

Local and long distance telephone service throughout Canada is provided by more than 2000 companies both investor-owned and public, serving over 8,000,00 telephones. The largest company is Bell Canada which serves almost all of the privinces of Ontario and Quebec. Each of the other provinces has a different primary system for local telephone service. Telephone service in the Yukon and the Northwest Territories, parts of Newfoundland and northern sections of British Columbia, is provided by Canadian National Telecommunications. By virtue of the heavy investment required to establish the distribution network, each company effectively has a monopoly within its own territory and is subject to federal, provincial, or municipal regulation depending upon the company's charter and circumstances.

Trunking of long distance calls is provided by the Trans-Canada Telephone System (TCTS) which is an informal association consisting of eight full member telephone companies (Alberta Government Telephones, the Bell Telephone Company of Canada, the British Columbia Telephone Company, Manitoba Telephone System, The Newfoundland Telephone Company Ltd., the New Brunswick Telephone Company,Ltd Maritime Telephone and Telegraph, and Saskatchewan Government Telephones). The Canadian Overseas Telecommunications Corporation (COTC) is an associate member. Every telephone system in Canada has access to this national and international network through the facilities of one of the member companies.

Telegraph and Cable

Canadian National and Canadian Pacific Telecommunications operate the national telegraph systems. These companies maintain telgraph offices, often amalgamated, in all 10 provinces and in the Yukon and Northwest Territories. CN/CP interconnect with the COTC, Western Union International, and Commercial Telegraph Corporation for international transmission, and a customer may elect the carrier through which he wishes the message sent. Although at one time the telegraph message was a prime source of CNT and CPT revenue, today such traffic asscounts for only 15% of total revenue for these divisions. Messages are transmitted by teleprinter and facsimile equipment and the telegraph networks over which public messages flow are computer-controlled.

Microwave Facilities

There are extensive transcontinental microwave systems in operation in Canada, placing Canada as the second highest among the world's users of microwave communications systems on a miles per capita basis. The Trans-Canada Telephone System and CN/CP Telecommunications provide transcontinental microwave systems for the transmission of telephone, television, data, and other communications. Other systems link British Columbia, Alberta, Ontario, and Quebec with the Far North. Some organizations such as provincial hydro and power authorities maintain private microwave systems for their own communications purposes. The two main Canadian television interests - the CBC and the CTV Television networks - lease microwave facilities for the relay of television programs from coast to coast, and the Department of Communications has opened a microwave band for the use of various Canadian educational authorities in an instructional television system.

Radio and Television Broadcasting

Canadian broadcasting is a combination of public and private enterprise. Today radio service reaches 99%, and television service reaches 96% of the Canadian population. The Canadian Broadcasting Corporation is a Crown Corporation established by an Act of Parliament to provide the national broadcasting service in Canada. Its radio and television facilities extent from coast to coast and into the Arctic Circle. As of March 1, 1969, the CBC had in operation. 31 AM stations(in addition, many of the 267 privately-owned radio stations were affiliated with the CBC); 202 low-power relay transmitters; 7 of the 77 FM stations; 5 of the 11 short-wave stations, and 92 of the 331 television stations in Canada. All but 43 of the 239 privately owned television stations were affiliated with the CBC; eleven of the unaffiliated private television stations form the CTV Television Network Limited, and the remaining are independent of network affiliation. The CBC is financed mainly by public funds voted annually by Parliament but supplementary revenue covering about 20% of operating expenses is obtained from commercial broadcasting. The privately owned broadcasting stations are dependent almost entirely on advertising revenue.

In addition to federally-supplied radio communication services, the provinces have established extensive radio communication systems for police, highway, and forestry protection purposes.

Other Services

The major telephone companies, CNT and CPT, all provide other services aside from public telephone and telegraph service. The major telephone companies now provide services such as TWX, Data-phone service, Data-line service, Multicom, Wide Area Telephone Service (WATS), Private Wire teletype service, and computer controlled transmission systems. CN/CP Telecommunications has been established as a joint venture to supply services throughout Canada in competition with the

TCTS in this area of video and data transmission and private line offerings of all types. To this end, CN/CP Telecommunications provide the following services - Telex, Broadbank Exchange Service, Hot-line service, Private Wire Teletype systems and computer controlled transmission systems. Brief descriptions of these services follow:

TWX and Telex. Telex, a Canadian teletypewriter service, is provided by CN/CP Telecommunications, with interconnection to world-wide networks, permitting a subscriber to dial directly any other subscriber on the network. There is no minimum charge and costs are determined on a time-used and distance basis. The major telephone companies provide a similar system called TWX, which also has international connections.

Data-phone service. The Data-phone service, operated by the major Canadian telephone systems, transmits data from punched cards, tape or magnetic tape between 2 or more machines or computers. The subscriber pays for the line which is being used at regular long distance rates.

Data-line service. The Trans-Canada Telephone System put this service into operation late in 1968, primarily for customers who wished to be connected to time-sharing computers. Charges are based on a flat rate and depend upon the band width used.

Multicom service. The Trans-Canada Telephone System has recently introduced a data communications network which initially features very high transmission speeds up to 60,000 words per minute. The service may be used for transmitting data directly from computer to computer, or for sending large batches of data for processing on remotely located computers. Also, data may be sent and received simultaneously. Rates are composed of a flat monthly service charge, cost of terminal equipment and transmission time and distance used with a six-second minimum calling time and additional six-second increments.

Wide-Area Telephone Service. This service, colloquially called WATS, is operated by the TCTS and provides dial-type telephone communication from one WATS zone directly to another lond-distance zone, without regular long distance charges on individual calls. Subscribers are charged on a measured time period rate and an additional hourly rate.

Private-wire teletype systems. In past years many companies rented private teletype networks from telecommunications companies. Many are now changing over to the newer computer-controlled transmission systems.

Computer-controlled transmission systems. CNT, CPT, and the TCTS all have in operation so-called "store and forward" message switching computers which control the flow of message traffic. These systems convert transmission codes and speeds and determine where messages are to be sent. CNT's system provides a switching medium for Air Canada, CP Air, and CN administrative message traffic, and also controls and transmits information on CN's reservation system. CNT's third generation message-switching computer switches commercial telegrams across the country.

Broadband and Exchange service. In 1967 an advanced design of an automatic switching system was introduced by CN/CP Telecommunications. This system has the capability, upon customer demand, of transmitting computer data at 51,000 words per minute, or more than 50 times faster than the top speed reached by conventional switched networks. Transmission is carried by the CNT-CPT microwave system using frequency diversity techniques to provide a high degree of reliability.

Hot-line service. CN/CP Telecommunications and Western Union offered in 1969 a Hot-line service whereby companies in Toronto or Montreal may talk to their offices in New York City by simply picking up the handset of the telephone. Subscribers are charged on a time-used basis.

c) Government Regulation of Telecommunications

The Department of Communications

The growing importance of telecommunications in indicated by the creation, through the Government Organization Act, 1969, of a federal Department of Communications. The duties of the Minister of Communications involve matters relating to telecommunications and the development and utilization generally of communications undertakings, facilities, systems and services for Canada. To exercise his powers and carry out his duties and functions, the Minister of Communications is empowered under the Act to:

a) co-ordinate, promote, and recommend national policies and programs with respect to communications services including the Post Office;

b) promote the establishment, development, and efficiency of communications systems and facilities;

c) assist Canadian communication systems and facilities to adjust to changing domestic and international conditions;

d) plan and coordinate telecommunications services for departments, branches and agencies of the Government of Canada;

e) complete and keep up-to-date detailed information in respect of communications systems and facilities and of trends and developments in Canada and abroad relating to communication matters; and

f) take such action as may be necessary to secure, by international regulation or otherwise, the rights of Canada in international communication matters.

The Regulatory Agencies

In an industry such as the telecommunications industry where the size of the market may be small in relation to the capital investment required to provide service, the government usually considers it in the public interest to limit the number of firms in the industry and to regulate the price of the service. Accordingly, the various Canadian telecommunications systems are regulated by various boards or commissions deriving their authority from statutes which define the powers and functions of that regulatory body in relation to the particular telecommunications system.

Telephone and telegraph companies incorporated under the federal Parliament are subject to the jurisdiction of the Canadian Transport Commission in the matter of rates and practices under the provisions of the Railway Act, while the other major companies are subject to provincial regulation. The International Telecommunication Convention and its regulations, and regional agreements, set down the procedures for international telegraph and telephone communications. Radio communications in Canada are regulated mainly under the Radio Act, the Canada Shipping Act, International Conventions

on shipping, aviation, telecommunications, and by regional agreements. All broadcasting for the public in Canada is regulated under the Broadcasting Act, which is administered by the Canadian Radio-Television Commission (CRTC).

CN Telecommunications is a federal Crown Corporation, while CP Telecommunications is investor-owned, but both are federally regulated by the Canadian Transport Commission under the Railway Act.

Bell Telephone Company of Canada and British Columbia Telephone Company also operate under Federal jurisdiction exercised by the Canadian Transport Commission under the Railway Act and the Acts of Incorporation of these two companies. The other members of the TCTS (with the exception of Saskatchewan Government Telephones) operate under provincial regulation, exercised by means of an administrative board or commission whose powers generally flow from the Public Utility Act of that province. Saskatchewan Government Telephones reports directly to the government of Saskatchewan. The municipal systems, such as the City of Edmonton Telephone System, are generally subject to municipal regulation.

Regulation of Rates

The general principle governing the regulation of rates in the telecommunications industry is that they be "just and reasonable", and not be discriminatory against any person or company. Since there is no encompassing statutory test of justness and reasonableness, varying tests have been used by the regulatory bodies at different times and places. In the setting of rates and charges it has been the practice of the particular regulatory board of commission to allow a certain rate of return on the "value" or rate base of the telecommunications firm in question. As examples, the following are descriptions of the various ways the rates of telephone companies across Canada have been determined at one time or another.

In the provinces of Newfoundland, Nova Scotia, Alberta and British Columbia, the rates are tested by formulae using the rate of return on a rate base calculated on a valuation of plant in service plus allowances for

items such as working capital. There is no specified test in New Brunswick, Quebec and Manitoba, but the rates must be "just and reasonable". In Manitoba there is a list of specific factors to be taken into consideration. In Prince Edward Island the rate of return is calculated on a rate base fixed by the regulatory authority. In Saskatchewan, the test of rates for the rural telephone systems is that they be sufficient to pay operating and other costs. The municipal systems in Ontario must set rates sufficient to meet the payments of principal and interest on debentures. The larger systems are permitted to earn a prescribed rate of return on capital invested.

However, there is now some indication that the setting of a permissive rate of return (however determined) should not be used as the sole test of the reasonableness of rates. In a 1969 judgement regarding a Bell Canada rate increase application, the Canadian Transport Commission stated that the effects of continuing changes in the economy upon the present financial position of Bell "illustrate the fallacy of attempting to establish as a sole test of the justness and reasonableness of rates, a maximum permissive rate of return ... no statutory requirement exists for the fixing of a rate base and a rate of return on that base. Therefore our decision is not to fix any permissive level at this time, but we propose to maintain constant surveillance over Bell's affairs and take any steps that may in the future call for further relief or for remedial action".

It may be noted here that the Railway Act (which governs the rates for Canadian National Telecommunications, Canadian Pacific Telecommunications, Bell Telephone Company of Canada and British Columbia Telephone Company, has recently been amended by Bill C-11, entitled "An Act to Amend the Railway Act", so that the Canadian Transport Commission will, when the amendment is proclaimed, possess the authority to regulate tolls for use of presently unregulated services and facilities.[1] Previously, "private wire" services, that is, the use of telegraph or telephone wires where no toll was charged to the public, were exempt from CTC regulation.

---

[1]The Canada Gazette, June 20, 1970 states that Bill C-11, received Royal Assent March 12, 1970 and is to come into force August 1, 1970.

4. The Role and Importance of the Telecommunications Sector

The telecommunications industry is a large contributor to the national output, is itself a large consumer of goods and services, and is also a large employer. To quote a few figures, in 1968:

The combined annual revenues of the common carrier telephone and telegraph companies totalled $1.4 billion;

Together they employed over 75,000 persons, paying an aggregate of $494 million in wages and salaries;

Their combined investment in plant and equipment was nearly $6 billion;

The total number of telephones in the country at year end was 8.8 million, and the total number of telephone conversations recorded during the year was more than 14 billion.

Tables I, II, III, and IV give short summaries of the operating revenues and expenditures for the telephone, telegraph, radio and television broadcasting, and communications equipment manufacturing industries.

An alternative view of the role of the telecommunications sector may be obtained by examination of input-output tables for the Canadian economy. Computations from the 1949 table reveal that

A dollar of output of the communications sector represented payments of:

41.6¢ to wages, salaries, and supplementary labour income;
9.1¢ to firms in the same sector, for services;
7.0¢ to firms in transportation, for services;
3.2¢ to firms in construction, for services;
16.5¢ to other sectors of the economy, for inputs;
3.1¢ on indirect taxes;
9.2¢ on depreciation allowances;
10.3¢ on income to capital employed in the sector.
100.0

Excluding sales of firms in the telecommunications sector to other firms in the same sector, the above breakdown shows that 70% of the value of output is attributed to primary inputs (labour and capital services), while 30% is attributed to the value of intermediate inputs purchased from domestic sources. The value of imported intermediate services into the communications sector is negligible -- measured at .1% in 1949.

A dollar of output of the communications sector would be distributed in sales of:

35.5¢ to consumers
2.5¢ to government
62.0¢ to other firms as inputs, of which
- 13.2¢ flows to the service industries sector
- 9.1¢ flows to the communications sector itself
- 8.5¢ flows to transportation, storage and trade.

100.0

Again excluding intra-sectoral sales, one can say that the distribution of output has 42.7% of sales to domestic purchasers for final output, and 57.3% as intermediate inputs to further production. Again recorded exports of communications services are negligible.

Finally, working through the table, one may note that gross domestic production originating in the communications sector represented 1.36% of total gross domestic production in 1949, of which close to 3/4 may be interpreted as flowing, directly or indirectly, to consumption uses.

5. Conclusion

Emerging from these scattered observations is a picture of an industry dominated by Bell Canada and CN/CP among the common carriers, and by the CBC within the broadcasting subsector, with vertical integration back to suppliers, and some continuing horizontal integration as both Bell Canada and B.C. Telephone acquire other telephone systems. Government intervention through regulation of the common carriers as well as through the participation of Crown corporations in broadcasting (CBC), international telegraph, telephone, and cable (COTC), and domestic microwave (CN), (not to mention Telesat) is extensive. With continuing growth of demands for new services arising from innovations within sectors using communications services, as well as new modes of production and new products developed as a result of technical progress within the communications sector itself, there will be continuing need to articulate comprehensive public policies designed to maintain the viability of the sector without restrictions on the entry of new participants. Formulation of any such policies demands a general description of the economic character of the sector as a whole, and it is to that goal that this study is directed.

With this general outline of an analytical framework for our work, and the above thumbnail sketch of the telecommunications sector as a whole, we may now move on to investigate the statistical record of the sector's operations in more detail, and then to break the analysis down into study of individual statistical relationships.

TABLE I

Telephone Statistics; Summary

	Units	1968	1959
Capital Stock[1]	$ 000	1,657,588	730,875
Funded Debt	$ 000	2,089,386	916,791
Total Telephones	$ 000	8,818	5,439
Property and Equipment[2]	$ 000	4,120,614	1,903,782
Total Calls	$ 000	14,381,608	9,250,220
Total Revenue	$ 000	1,268,387	582,263
Employees	No.	66,699	58,826
Salaries and Wages	$ 000	436,543	240,691
Total Expenditures	$ 000	1,095,763	509,727

[1] Includes premium on capital stock.

[2] Less accrued appreciation.

Source: D.B.S. Catalogue No. 56-203

TABLE II

Telegraph and Cable Statistics: Summary

Summary	Units	1968	1959
Pole-line Mileage	No.	49,497	47,535
Wire Mileage	No.	573,276	486,875
Property and Equipment[1]	$ 000	358,491	186,298
Telegrams Out	No.(000)	8,830	14,438
Received from U.S.	No.(000)	843	1,954
Cablegrams[2]	No.(000)	4,057	2,487
Money Transfers	$(000)	45,163	25,589
Operating Revenues	$ 000	116,666	52,963
Employees[3]	No.	8,687	10,586
Salaries and Wages	$ 000	57,494	40,059
Operating Expenses	$ 000	86,426	43,512
Net Operating Revenues	$ 000	30,240	9,451

[1]Less accrued depreciation

[2]Includes wireless messages and transatlantic telex messages.

[3]Excludes commission operators

Source:D.B.S. catalogue No. 56-201.

TABLE III

Radio and Television Broadcasting Statistics (Summary)

(Thousands of Dollars)

			1962		1959
	Private Stations	CBC	Private Stations	CBC	TOTAL
Operating Revenue					
Broadcasting Revenue from					
a) Network & National advertising	104,106	26,612	52,101	20,788	62,275
b) local advertising	77,849	1,322	40,734	1,862	33,464
Other non-broadcasting operating revenue	13,716	1,926	8,349	556	4,132
Grants[1]	-	145,630	-	76,964	52,300
Total Operating revenue and grants	195,671	175,490	101,184	100,160	152,171
Operating Expenses[2]					
Wire line or microwave service	1,365	11,803	(3)	(3)	0
Telephone and Telegraph outside service	2,883	2,139	6,333	11,111	(3)
Other operating expenses	161,522	161,548	89,506	89,049	143,110
Total operating expenses	165,770	175,490	95,839	100,160	143,110
Net operating income (loss) including grants	29,901	-	5,345	-	9,061
Average monthly number of employees	10,067	9,165	8,175	7,592	13,241

1 CBC charges its operations with depreciation, but deducts the charges on its published statements. The charge so made has been added to the government grant.

2 Does not include advertising agency commissions.

3 Figures not available.

Source: DBS Catalogue Number 56-204

TABLE IV

Communications Equipment Manufacturing and Electric Wire and Cable Manufacturing Statistics (summary)

	Units	Communications Equipment[1] 1968	1961	Electric Wire and Cable[2] 1968	1961
Establishments	No.	192	125	32	25
Manufacturing Activity					
Production and Related Workers	No.	27,820	15,018	5,833	4,403
Manhours paid	000	59,239	30,979	12,380	9,675
Wages	$000	144,700	57,520	37,052	19,888
Cost of fuel and electricity	$000	3,542	1,492	3,035	1,843
Cost of materials and supplied used	$000	285,718	93,750	206,914	103,253
Value of shipments of goods of own manufacture	$000	674,468	251,084	323,503	163,300
Value added	$000	386,452	162,423	110,303	62,983
Total Activity					
Working owners or partners	No.	14	9	-	-
Withdrawals	$000	65	38	-	-
Employees (total)	No.	43,117	24,000	8,343	6,541
Salaries and Wages	$000	248,880	108,753	55,973	31,504
Value added -- total activity	$000	402,276	169,567	112,242	64,158

[1] Source: DBS Catalogue Number 43-206

[2] Source: DBS Catalogue Number 43-209

Chapter II

The Historical Record

1. Introduction

Although the telecommunications sector (here taken to include telephone, telegraph and cable, and broadcasting) is still a relatively small sector in the Canadian economy, its importance has increased substantially in the last twenty years. The contribution of this sector to the economy was about 1.76 billion dollars in 1968, or approximately 2.5 per cent of the gross national product, compared to 2.0 per cent for 1958 and 1.6 per cent for 1950. Of the total contribution in 1968, close to three-fourths came from the "telephone industry", more than one-fifth from the "broadcasting industry", and the remainder from the "telegraph industry".[1]

From another point of view, the rapid growth of the telecommunications sector relative to the economy as a whole can also be seen in the large consumption expenditures on various telecommunications services and in the growing impact of this sector on capital formation and employment. Demand for total telecommunications service, as measured by operating revenues of this sector, has been growing at an average rate of 9% per annum in the last 12 years, a rate almost double that of GNP. In this chapter we review the historical movements of this sector for the past two decades. We must emphasize, however, that the main purpose of this review is to provide a "description" rather than an "explanation". While casual observation may occasionally suggest some tentative conclusions, systematic explanation is left to subsequent chapters.

---

[1] For percentage contributions of the "communications" sector to the Canadian economy over the recent past, see Table A in the appendix to this chapter.

In the next section, changing patterns of demand for various types of telecommunications service will be described. The following section reviews the structure and the level of prices charged on various telecommunications services, as well as on inputs required for providing these services. Historical trends in inputs of capital and labour and some measures of factor productivity in the telecommunications sector over the period will be analyzed in Section 4. Section 5 will be concerned with capital formation in the sector, while Section 6 depicts briefly the role played by the sector in the Canadian economy overall. Finally, comparisons of the regional distribution of, and regional trends in, telephone services will be made in Section 7.

2. Output

Telecommunications services in Canada are provided by the telephone and telegraph and cable common carriers providing two-way communication between specified individuals, and private or public broadcasting stations providing one-way transmission to a general audience. Since 1950, total service as represented by the revenues received by these three industries has been growing more or less steadily at an average annual rate of 9%. Between 1950 and 1967 it rose from less than a third of a billion 1967 dollars to close to 1.8 billion, a six-fold increase. Among the three subsectors, the telephone industry accounts for more than two-thirds of total revenue, a pattern which has remained virtually unchanged since at least 1956. Details of the supply-and-demand patterns for the period 1956-67, the period for which comparable revenue data for all three industries are available, are presented in Table B in the appendix to this chapter. Since we lack comparable breakdowns on various types of revenue in constant dollars, we shall deal with each industry separately in the discussion that follows.

We shall begin with the telephone industry. The telecommunications revenues generated by this industry have grown from 199 million dollars in 1950 to 1,268 million dollars in 1968, an impressive average annual rate of growth of 9.8%. In the same period population has grown at a rate of 2.4% per annum, from 13.7 million to 21.2 million. This means that the average Canadian spent $43.42 (directly or as an element in the cost of goods purchased) on various telecommunications services provided by the telephone industry in 1968, as compared with $8.70 in 1950. Even after taking into account the increased prices of telecommunications services (except long-distance rates, which have fallen), the per capita supply of or demand for "telephone" services, as measured by constant dollar revenues per head, has still grown at a handsome rate of 6.6% per year, well above the rate of growth of per-capita gross national product in constant (1967) dollars (2.0% per year).

Although the rapid increase in demand for total "telephone" services in the past is impressive, the growth of demand for different types of services is far from uniform. In general, the evidence suggests that, although the conventional voice message is still the dominant form of "telephone" service, the great advance in telecommunications services in the past decade has been in machine-to-machine communication. Transmission of computer data from one location to another has apparently grown so rapidly during the past few years that within a very short time the volume of data communications may, as predicted by many in the field, exceed that of voice communications. Unfortunately, however, precisely how rapidly machine-to-machine communication, voice messages, and other communications services have grown is unknown, since present records frequently do not separate services in these categories. With the available data, about all that we

can do is to compare the changes in the pattern of telephone services in the following three categories: "local", "long-distance", and "other" (including advertising, rental, and miscellaneous). This last category includes all revenues from leased private wire.

Among these three categories, toll telephone has advanced most quickly, rising from $70 million in 1950 to $461 million in 1967, an average annual rate of increase of 10.7%. Compared with the average rate of growth of 9.4% per annum for revenue from local services and of 8.6% for revenue from other sources, the dramatic growth in the demand for long-distance telephone services in the past two decades is obvious. This comparison, however, does not take into account changes in the prices of different telephone services. Throughout this period long-distance rates decreased; the price for local telephone services remained virtually unchanged, and the prices of other services (as well as of most other goods) increased steadily. Prices for operator-handled messages or other special services have risen steadily.[2] In view of these price changes, the differences in the rates of growth of different telephone services are considerably understated by the current-dollar figures. If we apply the price indexes derived by Bell Canada for their revenues[3] to the telephone industry as a whole, the annual growth rate of toll service rises to 12.9% between 1952 to 1967, compared with 8.6% for local services and 6.8% for other services. The changes in the distribution of telephone services for the period 1952 to 1967 are shown in Table I.

---

[2] See next section below.

[3] These indexes are reported in R.E. Olley, "Productivity Gains in a Public Utility -- Bell Canada 1952 to 1967", paper delivered at the Annual Meeting of the Canadian Economics Association, Winnipeg, June, 1970.

TABLE I

Patterns of Telecommunications Services - The Telephone Industry

(percentage distribution)

Year	Local Services (1)	Toll Services (2)	Other Services (3)
1952	59.8	28.6	11.6
1953	59.1	28.8	12.1
1954	58.9	28.4	12.7
1955	58.7	29.9	11.4
1956	58.2	30.7	11.1
1957	57.8	30.7	11.5
1958	58.2	30.7	11.1
1959	58.2	31.7	10.1
1960	58.7	31.7	9.6
1961	58.2	32.5	9.3
1962	56.8	33.9	9.2
1963	57.8	43.2	8.0
1964	56.4	35.9	7.7
1965	55.0	37.4	7.6
1966	53.6	39.1	7.3
1967	52.6	39.6	7.8

Services are measured by various types of revenue (reported in DBS *Telephone Statistics*) deflated by Bell Canada's revenue deflators (taken from Olley, *op. cit*.).

From this table it is evident that, as a proportion of total revenue, "toll services" is increasing substantially, while "local services" and "other services" are both declining, despite the fact that the introduction and continued expansion of Extended Area Service has the effect of transferring revenues from the "toll" category to the "local service" category.

Since the category "other services" includes revenues from leased lines, it is inctersting that the proportion of revenues in this category should be falling. On the other hand, many data transmission services are included within "other toll" revenue, and this (along with the declining relative price alluded to earlier) helps to account for the rapid growth of toll revenue. Although it is impossible to make any direct observations on this point from the information for the telephone industry as a whole, evidence from Table C in the appendix to this chapter and data provided by Bell Canada and CN/CP Telecommunications supports this argument. For instance, by far the fastest growth in Bell Canada revenue is achieved in the "other toll" component which includes revenues from Telepak, TWX, WATS, and broadband.[4] In constant (1967) dollars this category grows from $1.6 million in 1952 to $45.1 million in 1967, implying an average rate of increase of 25% per year. An even higher rate of growth occurred in CN/CP revenues from Telex and broadband services, for between 1958 and 1967 these grew a a rate of 27.2% per annum, which surpasses the growth rates of the other services offered by CN/CP Telecommunications.

Let us now turn to the telegraph and cable industry. This industry supplied 117 million dollars worth of telecommunications services in 1968, which accounts for nearly seven percent of the total services originating from the telecommunications sector. Over the past nineteen years, "telegraph"

---

[4] Olley, op. cit.

services have been growing in gross terms at an average rate of 8.1% per annum, which is slower than that of the "telephone" services. Primarily, this is the result of constant decline in the demand for telegraph messages. In constant (1967) dollars, revenue from public messages increased slightly from 27.8 million dollars in 1950 to 32.9 million dollars in 1953; since then it has been declining steadily to a low of 12.1 million dollars in 1968, nearly a three-folds reduction. This declining trend is also reflected in the number of telegrams transmitted, for between 1952 and 1968 the number of telegrams transmitted by the telegraph and cable industry fell from 19.0 million to 7 million.

There are, of course, other "telegraph" services whose growth rates are nil or very low and which are also responsible for a slower rate of growth for the total telegraph services. These are cables, press messages, money order services, and messenger errand. On the other hand, as pointed out earlier, the fast growth in the telegraph services is in the telex and broadband. The time pattern of these and other telegraph services is given in Table II.

Since the first radio station opened in 1918, the service provided by the broadcasting industry has grown to startling prominence in the daily life of the Canadian family. At present, radio broadcasting reaches about 99 percent and television broadcasting more than 96 per cent of the Canadian population. In the past 13 years total broadcasting service, as measured in operating revenues (including government grants to CBC), has grown at an average rate of 8.6%, from 132.2 millions of constant (1967) dollars in 1956 to 357 million in 1968. The fastest growing service

TABLE II

PATTERNS OF TELECOMMUNICATIONS SERVICES -
THE TELEGRAPH AND CABLE INDUSTRY

(percentage distribution)

Year	Public messages, cable and money order (1)	Private wire and rentals (2)	Broadcast (3)	Telex (4)	Others (5)	Total (6)
1956	66.9	27.0	4.3	0	1.8	100
1957	63.2	30.3	4.7	0.2	1.6	100
1958	56.3	34.0	5.1	1.6	2.9	100
1959	49.0	34.9	5.2	6.2	4.7	100
1960	44.2	36.2	5.8	8.8	5.0	100
1961	40.6	38.4	5.8	10.0	5.3	100
1962	36.5	41.8	5.4	11.5	4.8	100
1963	33.6	43.3	3.4	14.2	5.5	100
1964	30.7	42.5	3.5	16.9	6.2	100
1965	28.2	40.2	3.7	20.6	7.2	100
1966	23.8	40.4	3.6	24.3	7.8	100
1967	21.6	38.5	3.8	27.1	9.0	100
1968						

Source: calculated from data provided by CN-CP Telecommunications

provided by this industry is achieved in the "other" category which includes studio rentals, special program royalties, and miscellaneous non-broadcasting revenue. This component has grown at an average of 22.5% per annum, compared with a rate of 7.0% per year for local advertising, 8.2% for network advertising, and 9.5% for federal government grants. The comparison of distribution of services provided by the broadcasting industry is presented in Table III.

3. The Level and Structure of Product and Factor Prices

In the above we have taken deflated operating revenues as a measure of telecommunications services. Undoubtedly, such a measure will depend, among other things, on the level as well as the structure of rates charged on various services, which in turn are related to the costs of the service. It is , therefore, desirable to see the historical trends of prices and costs of the services. In this section only product and factor prices are discussed. Quantities of inputs will -- along with measures of factor productivity -- be given in the next section.

Consider first the structure of telephone rates. The domestic structure of telephone rates is highly differentiated and, in large part, discriminatory for the purpose of attracting as many customers as possible. Essentially, telephone rates must be distinguished between the two types of basic (local and toll) services on the one hand and special services and equipment on the other. For the local-exchange service, the customer pays a monthly rate which, with a few exceptional cases, does not depend on the number of calls but depends on the size of the local exchange area and on the number of extension and party lines. For example, in the

TABLE III

PATTERNS OF TELECOMMUNICATIONS SERVICES - THE BROADCASTING INDUSTRY

(percentage distribution)

Year	Nation-wide Advertisement (1)	Local Station Advertisement (2)	Other Sources (3)	Government Grant (CBC) (4)	Total (5)
1956	37.2	25.9	1.0	35.9	100
1957	39.2	23.0	2.7	35.1	100
1958	37.3	21.0	2.9	38.8	100
1959	40.9	22.0	2.7	34.4	100
1960	39.7	21.6	2.5	36.2	100
1961	36.2	21.3	3.7	38.8	100
1962	36.2	21.2	4.4	38.2	100
1963	36.6	22.5	3.2	37.7	100
1964	37.9	21.8	3.2	37.0	100
1965	37.7	22.2	3.5	36.6	100
1966	36.9	21.3	3.8	38.0	100
1967	35.2	20.3	4.0	40.5	100
1968	35.2	21.3	4.2	39.2	100

Services are revenues (available in DBS Radio and Television Broadcasting) deflated by GNP deflator.

areas served by Bell Canada with over 250,000 main telephones (such as Toronto and Montreal) the rate schedule is the following.[5]

Business services:	
One party line	$16.25 per main telephone per month
two party line	not offered
trunk line	$24.25 per month
Residence services:	
One party line	$5.85 per main telephone per month
two party line	$4.50 per main telephone per month
multi-party line	$4.00 per main telephone per month
extension phone	$1.25 per month.

Unfortunately, there is not enough information about the changes over time in local rates to put together a price index for local-exchange services for the telephone industry as a whole. The best approximation available is the price index for local revenue derived from Bell Canada data for the period of 1952-67, which is given in Figure 1. It is clear from this figure that the price of local exchange services edged up slowly between 1952 and 1958, but has remained steady since 1958.[6]

With respect to toll-telephone services, the rates vary according to a) distance, b) duration of a call, c) time of day and day of the week, and d) whether station-to-station or person-to-person. In general, toll

---

[5] These rates are provided by Bell Canada for the rate group #11.

[6] This could be about to change, however, for since September 1969, Bell Canada has been asking permission to increase local rates.

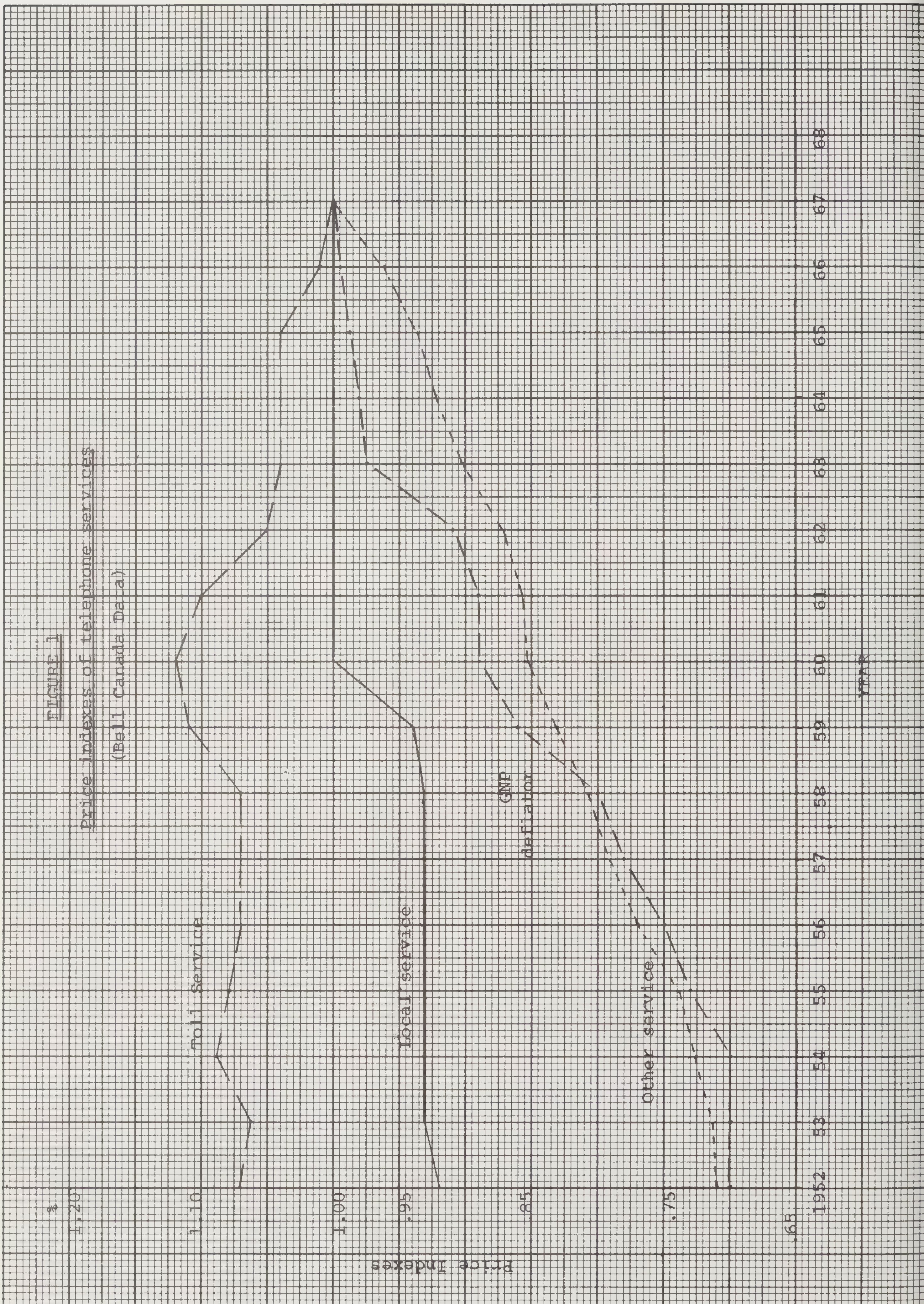


FIGURE 1
Price Indexes of telephone services
(Bell Canada Data)

charges increase with distance (but at a decreasing rate) and the duration of a call; rates are lower on station-to-station than person-to-person calls and higher during the peak business hours than during the night-time. A comparison of the toll cost for a five minute call between two points 350 miles apart is illustrated in Table IV and in Figures A to D in the appendix. Over the last two decades or so, charges on station-to-station calls have been either declining (in the case of intra-Bell toll calls) or increasing very slowly, at a rate much lower than that for person-to-person calls.

For a comprehensive picture of changes in the price of long-distance services as a whole, we must refer to the price index for toll revenue derived by Olley from Bell Canada data.[7] This price index is plotted in Figure I along with the other Bell deflators. It is readily seen from this figure that the price of toll service was virtually unchanged between 1952 and 1958 and increased slightly in 1959 and 1960; since 1961 the toll charge has fallen steadily.

Also in Figure I is the price index for other revenues such as directory advertising, rentals and miscellaneous categories derived from Bell Canada data. Since revenues in this category are from many different sources, one should expect the price to vary closely with the GNP deflator. Indeed, as may be observed from the figure, this is the case.

As mentioned above, the telegraph and cable industry provides a wide variety of domestic and international services. Unfortunately, however, most of the prices of these services are not easily summarized from the complex terms of the individual contracts governing equipment leasing or use.

---

[7]Olley, op. cit.

TABLE IV

Charge for 5-Minute Telephone Call

Between Points 350 Miles apart

(Three selected toll schedules)

Trans-Canada

Year	Day Station $	Day Person $	Night Station $	Night Person $
Sept. 1945	2.30	2.70	1.35	1.50
Jan. 1951	2.30	2.70	1.35	1.50
May 1953	2.75	3.30	1.85	2.40
June 1959	2.75	3.60	2.05	2.90
November 1960	2.75	3.60	2.05	2.90
May 1962	2.55	3.55	2.00	2.95
June 1964	2.55	3.55	2.00	2.95
March 1966	2.55	3.55	2.00	2.95
Sept. 1968	2.55	3.55	2.00	2.95

ONTARIO AND QUEBEC

Year	Day Station $	Day Person $	Night Station $	Night Person $
Sept. 1945	3.10	3.60	1.75	2.25
July 1950	3.10	3.60	1.80	2.30
November 1958	3.00	4.05	2.05	3.25
June 1959	3.00	4.05	2.05	3.25
Nov. 1961	2.10	3.40	1.55	3.40
March 1966	2.10	3.40	1.50	3.40
July 1968	2.10	3.40	1.50	3.40
October 1969	2.10	4.00	1.50	4.00
January 1970	2.10	4.00	1.50	4.00

U.S.A. (LONG LINES)

Year	Day Station $	Day Person $	Night Station $	Night Person $
March 1943	1.85	2.25	1.15	1.55
July 1945	1.85	2.25	1.15	1.55
February 1946	1.85	1.55	1.85	1.55
February 1960	2.10	2.70	1.40	2.00
January 1967	2.10	2.70	1.40	2.00
March 1969	2.10	2.70	1.40	2.00

The only information available to the public is the telegraph rates.[8] The rates for telegraph messages are determined by a) the air-line distance of the two points between which the messages are transmitted, b) the number of words per message, c) the type of service used, and d) geographical location of the service demanded. The rate for a fifty-word night letter is approximately 80 per cent of the charge for a fifteen word full-rate telegram. For reference, the current rate structure is given in Table V.

To measure variations over time in the telegraph rates we have constructed three sets of indexes.[9] Upon experimentation we found one set to be slightly better on statistical criteria, and this series is plotted in Figure II. The figure indicates that telegraph rates have increased substantially since 1950, a trend which presumably reinforces any shift toward long distance telephone service (whose rates are declining) as a substitute.

Costs of telecommunications services depend on prices as well as quantities of the inputs required in providing these services. At the aggregate level, inputs for telecommunications services are classified into capital (including land), labour, and intermediate goods. While satisfactory measures of inputs are hard to find, it is no less difficult to obtain information on input prices. For the capital stock, we have a telephone plant deflator constructed by Bell Canada from a survey of its telephone equipment and construction stocks in 1965. From Figure III, this index

---

[8] In conversation the people in this industry indicate that the charges on the services other than telegraph messages have undergone little or no change in the last decade.

[9] For a description of these indexes, see Chapter III of this report.

TABLE V

Rate Structures for Domestic Telegraph Services -- Atlantic Provinces

	Full-rate telegram			Night letter	
Air-line distance	15 words or less	next 10 words each word	each word over 25	50 words or less	each 10 words or less over 50
0 - 250	$1.05	.05¢	.02¢	$0.85	.17¢
251-450	1.20	.06	.03	1.00	.20
451-750	1.40	.07	.04	1.15	.23
751-1050	1.65	.08	.05	1.35	.27
1051-1600	1.90	.09	.06	1.60	.32
1601 + over	2.35	.10	.07	1.90	.38

Rate Structure for Domestic Telegraph Services -- All Other Provinces

	Full-rate Telegram			Night Letter	
Air-line distance	15 words or less	next 10 words each word	each word over 25	50 words or less	each 10 words or less over 50
0-250	$1.10	.05¢	.02¢	$0.90	.18¢
251-450	1.30	.06	.03	1.05	.21
451-750	1.55	.07	.04	1.25	.25
751-1050	1.85	.08	.05	1.50	.30
1051-1600	2.15	.09	.06	1.75	.35
1601 + over	2.50	.10	.07	2.00	.40

Source: Telegraph Tariff Book


Figure II
Price Index for Telegraph Message
%
1.05
.95
.85
.75
.65
.55
.45
1950
52
54
56
58
60
62
64
66
68
YEAR

suggests that the price of telephone plant as a whole has been relatively stable between 1952 and 1965, showing substantial gains only in 1966 and 1967. Together with the Bell Canada telephone plant deflator, Figure III also presents the price indexes for acquiring new physical plant by the telecommunications sector as a whole. Strictly speaking, these two sets of price indexes are not comparable since they are derived from different data and for different purposes. However, it is interesting to note that the prices of investment goods have risen faster than that of capital stock, reflecting at least partially the rapid technological progress in this sector.

For wage rates in each of the three telecommunications subsectors, the only comparable data are the average annual wages and salaries per employee of the individual industry; these data are presented in Table VI.[10] From Table VI one sees that average annual wages in this sector have increased steadily over the period under review, with those in the telegraph and cable industry growing at the fastest rate. Comparing wage rates among the three subsectors we find that the broadcasting industry appears to pay about 14% more per man per year than the other two subsectors, a result which presumably reflects the relative scarcity of positions for unskilled labour in this activity

[10] These measures suffer from many defects. Perhaps the most serious is that they do not take account of changes over time in the composition of labour inputs. This is especially obvious since 1958 when TCTS introduced direct-distance-dialing, which reduces the number of telephone operators relative to that of other categories of employees. Another defect arises from the fact that no adjustment is made for changes in the numbers of working hours. Even if these defects could be overcome, these measures still could not be taken as the annual wages of an average employee since, while the salaries and wages are for both full-time and part-time employees, the total number of employees reported for the telephone and the telegraph and cable industries are for full-time only. Despite these defects, however, these measures of labour cost are better than no measure at all.

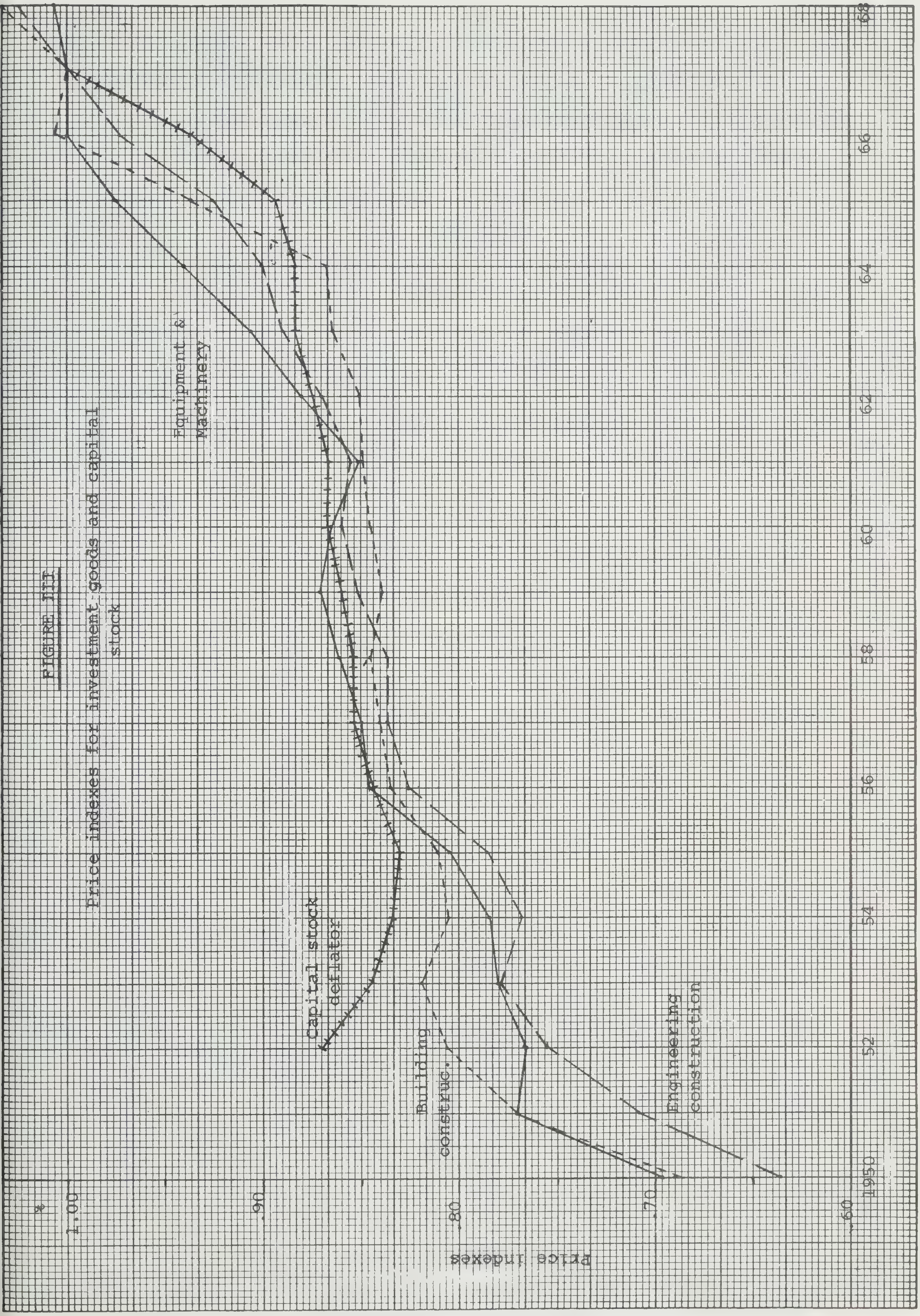


FIGURE III

Price indexes for investment goods and capital stock

For Bell Canada, we have a wage rate as well as the average annual wages of full-time employees; both of these are given in Table Vi. The only price index for intermediate goods available is for Bell Canada, and this, too, is included in Table IV.

TABLE IV

Average Wages and Price Index of Intermediate Goods for the Canadian Telecommunications Sector

Year	TELEPHONE $/man/yr. (1)	TELEGRAPH $/man/yr. (2)	BROADCASTING $/man/yr. (3)	BELL CANADA S/man/yr. (4)	$/hr. (5)	Price Index of Intermediate goods (6)
1952	2729	2645		3070	1.83	.7416
1953	2843	2907		3222	1.98	.7421
1954	3058	2960		3818	2.05	.7541
1955	3107	2997		3264	2.12	.7590
1956	3233	3204	3820	3500	2.20	.7855
1957	3438	3380	3965	3947	2.37	.8004
1958	3836	3560	4156	4351	2.52	.8127
1959	4085	3784	4478	4374	2.53	.8300
1960	4333	3848	4717	4558	2.68	.8414
1961	4536	4195	4834	4805	2.90	.8436
1962	4638	4227	5207	5027	3.10	.8569
1963	4931	4470	5415	5284	3.18	.8719
1964	5016	4817	5739	5397	3.25	.8948
1965	5317	5203	6050	5611	3.37	.9258
1966	5515	5648	6494	6019	3.62	.9673
1967	6000	6229	7236	6435	3.92	1.0000

Sources: (1) DBS Telephone Statistics

(2) DBS Telegraph and Cable Statistics

(3) DBS Radio and Television Broadcasting

(4), (5), and (6) R.E. Olley, "Productivity Gains in a Public Utility - Bell Canada, 1952-67"

4. Inputs and Productivity

Definitions of input vary with the context. In productivity studies, for example, inputs are supposed to represent the real (flow) contributions of factors to the production process; a choice of measures of input then cannot be divorced from the measurement of output. In reality, however, no such ideal measure is possible. At the industry level in the telecommunications sector, we have only stock measures such as employment as a measure of labour services, and costs of physical plant as a measure of capital service input to individual industries. For Bell Canada, in addition to these two measures we have data on manhours and intermediate goods.

In 1968 the Canadian telecommunications sector as a whole employed 96,000 people, accounting for about 1.3 percent of the total employed Canadian labour force; it also employed 9.1 billion dollars worth of capital goods[11] in the same year. Since the end of World War II, the labour force employed in the telephone industry has experienced a two-stage growth. Before 1957 and after 1961 the number of full-time telephone employees increased steadily, while in between these two periods this number declined significantly, apparently reflecting both the catching-up of deferred demand from World War II and the reduction of telephone operators as a result of the introduction of direct-distance-dialing. On the whole, however,

---

[11] This figure is the estimated cost of physical plant for this sector at the end of 1968 (DBS data).

the number of full-time telephone employees has grown at an average of 4.5% per year between 1941 and 1967.

In the telegraph and cable industry, the labour force has experienced a continued decline since 1958, from 11,000 employees down to less than 9,000 in 1968 (a decrease of 12 per cent). Presumably this decrease reflects the reduction in the number of employees (such as messengers) handling telegrams, and other impacts of general automation. Nevertheless, the average rate of change in the labour force of the industry between 1941 and 1967 is still positive at 0.8% per year. Employment in the broadcasting industry has been increasing over the last 13 years, with the rate of growth averaging 5.2% per year. Table VII sets out the number of employees in each industry for comparison. Also included in this table are data on manhours and number of employees for Bell Canada, which accounts for about two-thirds of the total telephone employees.

Table VIII shows that capital input, as measured by the cost of physical plant, has been growing steadily over the period. By 1967, the cost of physical plant had grown to $5,011 million for the telephone industry and $495 million for the telegraph and cable industry, almost five times that in 1952 for each industry. The average annual rate of increase in the capital stock over this period was 11.1% for the telephone industry and 10.8% for telegraph and cable.

For the telephone industry, we were able to construct special measures of net capital stock for equipment and construction taken separately. These are based on actual capital expenditures, a survival curve provided by Bell Canada for telephone plant, and on an assumed 5% annual decay of the existing capital

TABLE VII

Labour Input of the Canadian Telecommunications Sector

Year	Telephone Industry (No. of employees)	Telegraph and Cable Industry (No. of employees)	Broadcasting Industry (No. of employees)	BELL CANADA No. of employees	BELL CANADA No. of manhours (millions of hours)
1950	45396	9757			
1951	47387	10611			
1952	48207	11272		30,000	50.2
1953	50540	11618		31,100	50.7
1954	51929	10629		34,600	53.7
1955	55673	10852		37,800	58.2
1956	60121	10833	10498	39,400	62.7
1957	64074	11159	11930	39,200	65.3
1958	61400	10587	12896	37,000	64.0
1959	58826	10586	13241	35,000	57.8
1960	57670	10279	13885	34,000	54.6
1961	56322	9997	15514	32,900	54.5
1962	58091	10069	15767	33,600	56.1
1963	58416	9826	16160	33,800	57.3
1964	60829	9431	16624	34,500	59.0
1965	63467	9270	16892	35,500	62.3
1966	68154	9161	17925	37,500	60.4
1967	68431	8961	18946	36,800	

Sources: DBS _Telephone Statistics_

DBS _Telegraph and Cable Statistics_

DBS _Radio and Television Broadcasting_

R.E. Olley, "Productivity Gains in a Public Utility -- Bell Canada, 1952-67"

TABLE VIII

Gross Stock of Capital: Cost of Physical Plant of the Canadian Telecommunications Sector

(millions of current dollars)

Year	TELEPHONE INDUSTRY Cost of Plant	TELEPHONE INDUSTRY Accumulated Depreciation	TELEGRAPH AND CABLE INDUSTRY Cost of Plant	TELEGRAPH AND CABLE INDUSTRY Accumulated Depreciation
1950	807	218		
1951	910	234		
1952	1028	246	100.2	23.5
1953	1152	277	110.8	26.0
1954	1302	304	118.3	27.7
1955	1471	330	124.3	29.2
1956	1672	366	150.0	35.2
1957	1942	412	169.3	39.7
1958	2203	460	199.3	46.7
1959	2445	541	226.9	40.6
1960	2692	557	267.4	47.6
1961	2927	618	299.6	57.7
1962	3192	676	336.4	69.0
1963	3510	762	391.2	81.5
1964	3809	851	425.3	99.5
1965	4127	955	447.3	115.4
1966	4545	1069	474.8	133.3
1967	5011	1201	494.5	147.9

Source: DBS Telephone Statistics (Cat. No. 56-203)

DBS Telegraph and Cable Statistics (Cat. No. 56-201)

stock due to obsolescence. These series, which are tabulated in Table IX, along with the number of telephones and the net capital stock measure constructed by R.E. Olley for Bell Canada, have been used in the telephone investment equations in Chapter V.

Thus far we have only described the telecommunications sector by its historical record separately on output prices, employment, and capital stock. It would be interesting to relate these series to one another in a way which yields a more comprehensive picture of the sector. One of the most useful devices for this purpose is the construction of indexes of factor productivities. To this end, we have calculated crude measures of average factor productivity in the form of output-labour and capital-output ratios. These are shown in Table X.

It is apparent from this table that the average output-labour ratio for the broadcasting industry is higher than that for the telephone industry which in turn is substantially higher than that for the telegraph industry. While the telephone and the telegraph and cable industries require large numbers of operators and repairmen in customer service, the broadcasting industry requires many fewer such employees.

On the average, the productivity of the whole sector (measured by output per employee) increased steadily over the period 1956-67 at an average rate of 7.0% per year. Compared with the rate of growth of 4.1% in output per person employed for the Canadian goods-producing industries as a whole and 4.0% per year for the Canadian manufacturing sector for the same period, this rate of growth is surprisingly high. However, such a high rate of growth may not be unreasonable for this sector in view of the fact

TABLE IX

Net Capital Stock and Number of Telephones

Year	Capital Stock				Telephones		
	Equipment	Construction	Total	Net Capital of Bell Canada Adjusted by R.E. Olley	No. of Business	No. of Residence	Total
1950	574.3	391.0	965.3		902	2,016	2,918
1	621.8	434.0	1055.8		957	2,157	3,114
2	680.4	475.6	1156.0	600.7	1017	2,336	3,335
3	742.4	528.4	1270.8	660.7	1085	2,522	3,607
4	816.9	584.7	1401.6	733.9	1154	2,706	3,860
5	902.2	653.5	1555.7	835.8	1236	2,915	4,151
6	1006.4	721.2	1727.6	949.9	1334	3,615	4,499
7	1153.3	799.0	1952.3	1081.6	1409	3,418	4,827
8	1296.8	887.0	2183.8	1228.4	1486	3,632	5,118
9	1408.3	965.9	2374.2	1370.5	1569	3,870	5,439
1960	1515.9	1043.0	2558.9	1514.6	1674	4,054	5,728
1	1618.4	1092.2	2710.6	1648.1	1730	4,284	6,014
2	1754.8	1145.6	2900.4	1775.6	1817	4,513	6,330
3	1894.0	1196.3	3090.3	1914.8	1910	4,746	6,656
4	2016.8	1253.4	3270.2	2050.3	2016	5,003	7,019
5	2141.4	1315.4	3456.8	2177.3	2142	5,303	7,445
6	2310.8	1402.9	3713.7	2314.6	2290	5,603	7,893
7	2523.8	1474.1	3997.9	2464.5	2423	5,935	8,358

Sources: (1) Net Capital stocks of the telephone industry: constructed from investment series and Bell Canada's capital surviving curve (see Chapter V below)

(2) Nos of Telephone: DBS Telephone Statistics

(3) Net Capital stock of Bell Canada: R.G. Olley. "Productivity Gains in A Public Utility - Bell Canada 1952 to 1967"

TABLE X

Productivity of the Canadian Telecommunications Sector: Output-Labour and Capital-Output Ratios

	OUTPUT-LABOUR RATIO (CONSTANT 1967 $ PER EMPLOYEE)				CAPITAL-OUTPUT RATIO IN 1967 DOLLARS			
Year	Telephone Industry	Tel. & Cable Industry	Broadcasting Industry	Total Sector	Telephone Industry	Telegraph & Cable Industry	Broadcast. Industry	Bell Canada
1952	6167				3.9	2.2		3.1
1953	6471				3.9	2.1		3.2
1954	6942	4892			3.9	2.2		3.3
1955	7071	4884			3.9	2.2		3.3
1956	7383	4892	12574	7722	3.9	2.6	0.50	3.4
1957	8167	5108	12327	7969	4.0	2.7	0.50	3.6
1958	8656	5573	13377	8984	4.2	3.0	0.46	3.7
1959	9695	6046	13896	9900	4.2	3.6	0.47	3.8
1960	10737	6810	14044	10805	4.2	3.6	0.50	3.9
1961	11857	7602	13794	11704	4.0	3.7	0.53	3.8
1962	12586	8243	14905	12501	4.0	3.7	0.53	3.8
1963	13414	8650	15532	13264	3.9	4.1	0.53	3.8
1964	13967	9331	16422	13933	3.9	4.0	0.53	3.8
1965	14841	10032	17345	14816	3.7	3.7	0.55	3.7
1966	15368	11807	17908	15407	3.5	3.5	0.55	3.6
1967	17118	11717	19001	16985	3.5	3.4	0.53	3.5

Source: Calculated from Tables I, VII, VIII and IX.

that the introduction of automatic switching systems near the middle of the period sharply reduced the required number of telephone operators and thus raised the output-labour ratio. Indeed, had the output-labour ratio been calculated for the period 1950 to 1967, its value would be significantly smaller. This observation has been confirmed by Olley, using data for Bell Canada.[12] Moreover, even though our result is not strictly comparable with Olley's, it is worth noting that our rate of growth in output per employee for the total sector is still much below the average annual percentage changes of 10.1% in Bell Canada's output per man hour.[13]

Among the three subsectors, labour productivity in the telephone industry has grown the most rapidly over the period under review, rising at 7.9% per year compared to 7.0% per year in telegraph and cable and 3.7% per year in broadcasting.[14]

From the same table we also observe that the capital-output ratio in the telephone industry has been relatively stable (between 3.5 and 4.2) over the period covered. The peak was reached at the end of the fifty's, and reflects both the heavy investment and the slow increase in revenues which occurred during those years. The telegraph and cable industry had about the same capital-output ratio as telephone, except in the early fifty's .

---

[12] See Table 18 in Olley, op.cit.

[13] In the light of reduction in manhours worked per person, the rate of growth in output per manhour must be even higher than in output per employee.

[14] These rates are considerably higher than those of 6.3% for communications and 2.6% for radio and TV broadcasting estimated from U.S. data by Clopper Almon, Jr. in The American Economy to 1975 (Harper and Row, 1966), p. 127.

As for the broadcasting industry, the capital-output ratio is substantially smaller than that of telephone and telegraph and cable. Partially at least this is due to the fact that intermediate inputs, which are relatively more important in the operation of the broadcasting industry than in either telephone or telegraph and cable, have not been excluded in our output measure. Nonetheless the capital-output ratio would seem to be stable for the broadcasting industry over the period.

One may note that our estimates of capital-output ratio for this sector appear to be lower than those calculated by White.[15] The difference is in the fact that White's capital-output ratio is based on the gross stock of capital, while ours is based upon the net stock. Based on gross cost of physical plant, the capital-output ratio for both the telephone and the telegraph and cable industries between 1952 and 1963 is of the order of 5.54 as compared to an average of 5.85 estimated by White for the same period.[16]

---

15 D.A. White, Business Investment to 1970, Economic Council of Canada, staff study No. 5.

16 The remaining difference can be attributed to an exclusion of the Post Office and the fact that, while White used net income generated from the sector as his output measure, we use the gross product which includes the value of intermediate goods.

5. Capital Formation

A preliminary estimate by DBS of total investment outlays on new equipment and construction by the Canadian telecommunications sector (including broadcasting) in 1968 is 695.7 million dollars, which is about 21.4% of total investment expenditures by the utility sector as a whole, and 7.4% of national business fixed capital formation (excluding residential construction and inventory change). Of this total investment demand, over 90 percent was generated by the telephone industry. The remainder was divided almost equally between the telegraph and cable industry (5.2%) and the broadcasting industry (4.7%).

Although fixed capital formation by this sector has fluctuated with the whole economy (reflecting , in particular, the decline in 1959-61), it has nonetheless experienced substantial expansion over the last two decades. The average rate of growth in these outlays in constant (1967) dollars has been at a rate of 8.7% per annum, compared with an average rate of growth of 5.8% for total business investment in equipment and construction over the same period.

From the information set out in Table XI, it is possible to compare the patterns, as well as the rates, of growth in investment outlays by each industry. The first thing to note is that the fastest rate of expansion is achieved by the broadcasting industry: between 1950 and 1968, investment outlays by broadcasting grew at an average rate of 13%, compared to 7% for telephone and 9.2% for telegraph. The heaviest investment in broadcasting has been in the past few years, reflecting the introduction of colour TV and cable TV.

A second item of interest is the fact that between 1950 and 1968 the telephone industry passed through two periods of rapid growth, both associated primarily with the construction of Trans-Canada microwave systems by TCTS. The first period took place around 1954-58 during which the first Trans-Canada microwave system was completed. The second period began in 1965 and continued until the second microwave system was completed.

To compare the major forms of investment by the telephone industry over the period, Figure IV is provided. It is evident that investment outlays both on telephone equipment and machinery and on construction fluctuated roughly in concert, although expenditures for equipment and machinery expanded relatively faster than for construction. Among other things, this divergence implies that the impact on the economy of each dollar of investment by the telephone industry has been reduced since the import content of expenditure on equipment is normally higher than that of construction.

Gross investment of the telegraph and cable industry has been more volatile than that of telephone. Close to half of the 537.7 million 1967 dollars invested in total over the years from 1950 to 1968 were spent between 1960 and 1964, during which the CN-CP trans-continental microwave systems were constructed. In 1963 alone, 73.1 million 1967 dollars was invested, which is more than double the investment of any year before 1960 or after 1964.

TABLE XI

Capital Expenditure on Equipment and Construction
by the Canadian Telecommunications Sector

(millions of 1967 dollars)

Year	TELEPHONE			TELEG., RADIO & CABLE	BROADCASTING		
	Equip. & Machinery	Con-struction	Total	Total	Equip. & Machinery	Con-struction	Total
1950	96.0	69.8	165.8	5.9	1.4	1.6	3.0
1951	93.4	73.8	167.2	8.1	2.6	1.4	4.0
1952	108.4	76.0	184.3	14.2	2.6	2.6	5.2
1953	116.4	90.5	206.8	13.9	5.1	5.1	10.2
1954	133.8	98.3	232.7	17.4	11.5	5.2	16.7
1955	150.5	115.2	265.7	12.1	8.7	5.1	15.8
1956	176.1	119.5	295.7	20.3	5.9	4.8	10.7
1957	227.1	135.1	363.2	23.3	5.9	4.8	10.7
1958	235.2	151.5	386.7	23.4	8.1	2.4	10.5
1959	214.5	149.4	363.9	26.2	10.3	4.7	15.0
1960	219.7	153.9	373.5	48.2	17.3	9.2	26.5
1961	223.3	123.3	355.6	39.3	17.6	6.1	23.7
1962	265.6	140.7	406.3	43.7	10.2	4.8	15.0
1963	279.2	142.5	421.7	73.1	11.0	6.2	17.2
1964	274.2	153.1	427.3	43.4	17.0	6.3	23.3
1965	285.9	162.8	448.6	29.1	15.4	7.5	22.9
1966	341.0	193.2	534.2	31.9	39.0	8.0	47.0
1967	398.0	184.0	582.0	28.5	26.0	7.0	33.0
1968	404.2	214.2	618.3	35.7	24.8	6.8	31.6

Sources: DBS _Private and Public Investment in Canada_
DBS Business and Finance Division Data
DBS _Telegraph and Cable Statistics_


GROSS INVESTMENT OF THE TELEPHONE INDUSTRY
(1967 dollars)
Total
Equipment
Construction
Gross investment in millions of 1967 dollars
600
500
400
300
200
100
50
1950
52
54
56
58
60
62
64
66
68

6. Role of the Sector in Interindustry Flows

The input-output table for Canada for the year 1961 has just been published by DBS;[17] examination of this table reveals some interesting features and confirms some intuitive impressions as to both the character of the sector and its relation with other sectors of the economy. The telecommunications sector together with the Post Office appears as "communications" (#57) in the DBS 65-industry input-output classification. The communications equipment manufacturing sector appears as "manufactures of communications equipment including wire" (#44) in the same classification. In our discussions below, "communications equipment" refers to sector #44, "communications services" to sector #57.

Looking first at communications services, we see[18] that of each dollar of sales, only 22¢ goes to raw materials, the remainder being distributed to input services, 44¢ in wages and salaries, 2¢ in indirect taxes, and 37¢ to a package item representing profits, profits taxes, interest, dividends, and capital consumption allowances -- roughly, a payment for use of capital goods. The apparent excess of payments over receipts is balanced by a government subsidy of 6¢, recorded as revenue to the industry.

---

[17] DBS The Input-Output Structure of the Canadian Economy, 1961, Volumes I and II. Catalogue Nos. 15-501 and 15-502.

[18] DBS 15-501, Table 9.

Turning the question around, and asking what additional deliveries of materials or inputs of services would be required to deliver one additional dollar of final demand for telecommunications services, we see[19] that there would be 56¢ in wages and salaries, 44¢ in payments for capital service, 2 1/2¢ to unincorporated business and 3 1/2¢ of indirect taxes. The excess of 6¢ is paid to the industry as government subsidy.

The story is very little changed whan account is taken of import leakages[20], reflecting the fact that communications services create few demands for inputs that are provided from abroad. (In the present example, 2¢ of the 56¢ flowing to labour, and 1¢ of the 44¢ flowing to capital, would be diverted to imported services. Industry activity levels are very little affected.)

With respect to communications equipment, the importance of raw materials is greater. Of each one dollar value of sales, 49¢ may be imputed to primary services (37¢ to wages, 11¢ to capital, and 1¢ to indirect taxes) and 51¢ to raw materials. No subsidy is recorded to this industry.

Of the raw materials cost, one sees 12 1/2¢ to "other primary metals", 10¢ to intra-sectoral sales, 5¢ to financial services and operating supplies, and a penny or two to rubber products, conducting and refinery products, metal stamping, electronic equipment, plastics and synthetic resins, trade and transport, none of which is surprising.

---

[19] DBS 15-501, Table 10, ignoring all import leakages.

[20] DBS 15-501, Table 11.

Again turning the question around to consider the changes in industry activity levels and factor inputs required to produce one dollar of communications equipment for final demand, tracing all derived demands back to their primary inputs (but ignoring import leakages), one finds 66¢ in labour services, 28¢ in capital services, and 5¢ in indirect taxes or net income of unincorporated business. Taking import leakages into account, these numbers fall to 57¢, 23¢, and 4¢ respectively. Thus, of the dollar of final demand for communications equipment, 15¢ in factor payments ultimately flows abroad.

Thus, to summarize the conclusions from this review of the relationships shown in the input-output table, we may observe that the communications services sector is, in terms of direct inter-industry relationships, highly capital-intensive, and relatively less dependent on either raw materials or imported services. To serve an increased final demand of one dollar for telecommunications services would entail inputs which ultimately could be traced back to wage payments of 56¢ (2¢ abroad) and capital service or depreciation of 44¢ (1¢ flowing abroad) together with public subsidy of about 6¢ (presumably to post office activities or the CBC). Communications equipment manufacturing is apparently less capital-intensive, more heavily dependent on raw materials, and ultimately upon imported supplies. To provide for an increase in final demand of one dollar's worth of communications equipment entails a chain of increased inputs which ultimately can be traced back to wage payments of 66¢ (9¢ flowing abroad), capital payments (including depraciation) of 28¢ (5¢ flowing abroad), and other services of 5¢ (1¢ flowing abroad). Tables XII and XIII, which have been compiled directly from the DBS 1961

input-output tables, briefly summarize the direct and indirect effects on materials or service inputs of one dollar of final demand for communications services or communications equipment, with or without import leakages.

Although the DBS input-output table for the year 1949 is not strictly comparable with that for 1961, it is interesting to note that nearly 30 per cent of net output in communications services was paid out for intermediate inputs and 70 per cent for labour and capital services.[21] Only one-tenth of one per cent was for imported inputs. On the other hand, 57 percent of this net output was used by other sectors of the economy as intermediate products, and the remaining 42% was entirely for final domestic demand.[22] Tables D and E in the appendix set out separately the inter-industry flow of goods and services to and from communications.

---

[21] DBS 13-513, table 5.

[22] Ibid.

TABLE XII

	Communications Col. 57		Com. Equip. Incl. Wire, Col. 44	
	Table 10	Table 11	Table 10	Table 11
Metal Mines				.030
Rubber Prod. Mfg.			.018	
Pulp & Paper Mills			.015	
Print Publishing			.017	
Iron, Steel Mills			.053	.035
Smelt., Refining			.102	.072
Oth. Primary Metals			.135	.106
Metal Stamping			.022	.016
Other Metal Mfg.			.036	.025
Machinery(Nec) Mfg.			.017	
Elec. Ind. Equip.			.037	.028
Com. Equip. & Wire			1.053	1.022
Oth. Elec. Prod. Ind.			.039	.036
Plastic, Syn. Resin			.024	
Oth. Chem. Ind.			.034	.017
Misc. Mfg. Ind.			.023	.016
Construction	.040	.039	.017	
Trade, Wh. & Retail	.024	.022	.057	.047
Transport, Storage	.073	.069	.046	.036
Communications	1.025	1.024	.019	.016
Utilities			.024	.018
Fin. Insur., Rl. Est.	.025	.023	.049	.042
Other Services	.038	.035	.017	
Advrtg. & Travel			.033	.027
Operating Suppl.	.019	.017	.061	.050
Subsidies	-.064	-.063		
Indir. Tx. & Gov. Ser.	.034	.033	.026	.021
Wages & Salaries	.556	.540	.661	.575
Net. Inc.-Unincorp.	.025	.023	.025	.020
Surplus	.439	.430	.282	.228

Source: DBS Cat. No. 15-501 (1961), Vol. 1, Table 10-Impact Table Without Import Leakages and Table 11-Impact Table With Import Leakages.

TABLE XIII

	Commun. Equip. Col. 134		Elec. Wire& Cable, Col. 135		Radio & TV Equip.,Col. 137		Broadcast. Col. 181		Tel. & Tel. Col. 182	
	T. 15	T. 16	T. 15	T. 16	T. 15	T. 16	T. 15	T. 16	T. 15	T. 16
Base Metal Mines	.059	.038	.064	.042	.033	.019				
Oth. Rubber Ind.					.022	.015				
House Furniture					.022	.020				
Pulp & Paper Mills					.019					
Paper Box & Bag Mfg.					.015					
Print-Publishing	.017		.017		.028	.021	.019	.015	.019	.015
Iron & Steel Mills	.031	.020	.028	.018	.051	.037				
Smelting & Refining	.143	.105	.154	.115	.080	.051				
Alum. Roll. Cast.	.039	.029	.049	.039	.018	.011				
Copper Roll. Cast	.086	.077	.091	.082	.025	.017				
Metal Stamping	.022	.016	.018	.013	.016					
Vehicle Parts Mfg.					.045	.037				
Comm. Eq. & Wire Mfg.	1.027	.990	1.099	1.062	.227	.155				
Elec. Indust. Eq.	.044	.034	.028	.019	.041	.027				
Oth. Elec. Prod. Ind.	.057	.052			.975	.962				
Glass & Prod. Mfg.					.017					
Plastic Resin Mfg.	.024	.013	.024		.023	.012				
Other Chem. Ind.	.032	.015	.032	.015	.039	.018				
Misc. Mfg. Ind.	.027	.021	.016		.026	.017				
Construction	.017		.017		.017		.040	.039	.040	.039
Wh. & Retail Trade	.055	.045	.053	.045	.072	.060	.021	.019	.025	.023
Trans. & Storage	.044	.035	.043	.034	.064	.052	.072	.069	.072	.069
Communications	.019	.016	.018	.015	.023	.019	1.027	1.026	1.024	1.023
Utilities	.024	.018	.024	.018	.024	.017				
Fin. Insur. Rl. Est.	.049	.042	.049	.042	.052	.042	.027	.024	.027	.024
Hotel Restaurant					.020	.018				
Other Services	.016		.016		.018		.038	.034	.038	.034
Advrtg. & Travel	.033	.028	.031	.026	.065	.058	.015	.014	.015	.014
Operating Suppl.	.058	.048	.058	.048	.060	.047	.019	.017	.019	.017
Subsidies							-.063	-.063	-.063	-.063
Indir. Tx. & Gov. Ser.	.026	.021	.026	.021	.028	.022	.035	.034	.035	.034
Wages & Salaries	.657	.570	.657	.571	.634	.517	.558	.541	.558	.541
Net Inc. Unincorp.	.023	.018	.023	.018	.031	.024	.020	.019	.021	.019
Surplus	.288	.232	.289	.233	.300	.235	.441	.431	.441	.431

Source: DBS Cat. No. 15-502 (1961), Vol. 2, Table 15-Impact Table Without Import Leakages and Table 16-Impact Table With Import Leakages.

7. Regional comparisons -- The Telephone Industry

In 1967 there were 8.4 million telephones in Canada, of which 39.2 per cent were in Ontario, 27.5 per cent in Quebec, 10.4 per cent in the Pacific Region (British Columbia, Northwest Territories and the Yukon), 15.8% in the Western Region (Alberta, Saskatchewan and Manitoba) and the remaining 7.1 per cent in the Atlantic provinces. Compared with the distribution of population in that year, only Ontario and British Columbia had more telephones than would be forecasted by their populations.

A similar pattern of regional distribution prevails in almost every type of telephone service and inputs of the telephone industry. In 1967, for example, 66.6 percent of the total telephone service (as measured by revenues) was provided in the Central Region (Ontario and Quebec), 11 percent in the Pacific Region, 15.9 percent in the Western Region, and 6.6 percent in the Atlantic Region. With respect to the full-time telephone employees in Canada, however, the scene is a little bit different; only 60.3 percent of the full-time telephone employees were in the Central Region, 11.1 percent in the Pacific Region, 21.3 percent in the Western Region and 8.2 percent in the Atlantic Region. This presumably reflects the fact that the telephone systems of the Central Region are more mechanized than those in the Western Region. Indeed, of the 1,848 small co-operative types of telephone systems in 1967, 1,734 were in Alberta and Saskatchewan. Table XIV sets out for comparison the distribution of several variables relating to the telephone industry.

TABLE XIV

Provincial Distribution of Population, Output, and Inputs of the Telephone Industry, 1967

(Percentage)

	Population	Number of Telephones	revenue from Local services	revenue from long-dist. services	rev. from other services	total revenue	cost of plant	full-time employees	salaries and wages
NWT & Yukon	0.1	0.1	11	-	-	-	-	-	-
Brit. Columbia	9.5	10.3	1	10.8	10.3	10.9	11.1	11.1	11.8
Alberta	7.3	7.2	6.2	10.2	7.1	7.9	8.4	10.7	10.2
Saskatchewan	4.7	4.0	2.7	4.7	11.1	4.2	4.7	4.8	3.6
Manitoba	4.7	4.5	3.3	4.6	3.2	3.8	4.6	5.8	5.5
Ontario	35.0	39.2	70.9*	61.6*	63.1*	66.6*	64.4*	60.3*	62.0*
Quebec	28.8	27.5							
N. Brunswick	3.0	2.4	2.1	3.5	1.2	2.6	2.7	2.9	2.8
Nova Scotia	3.7	3.0	2.8	3.2	1.3	2.8	2.9	3.8	2.9
P. E. Island	0.5	0.4	0.3	0.3	0.1	0.3	2.8	0.3	0.2
Newfoundland	2.5	1.3	0.9	0.9	0.3	0.9	0.3	1.3	1.1
CANADA	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

*Includes data of Bell Canada operations in Newfoundland, Ontario, Quebec and the Northwest Territories.

Source: calculated from DBS National Accounts: Income and Expenditure and Telephone Statistics

In the 1950-67 period, all provinces showed remarkable growth in telecommunications services, although the rates of growth are far from uniform for all types of services in all regions. This may be illustrated by the regional rates of growth of the telephone industry, which is the only sector for which regional data are available. For example, the average annual rate of growth in local-telephone service in this period ranged from a low of 5.9% for Saskatchewan[23] to a high of 12.6% for Newfoundland. As can be seen from Table XV, these large differences among provinces in the average rate of growth also prevail in toll telephone and other telephone services. Newfoundland recorded the fastest annual rate of growth in local telephone services (12.6%), toll telephone services (19.3%), number of residence telephones (10.9%), number of full-time employees (8.4%), and wage bill (15.2%). And the rate of growth in the number of business telephones at 7.5% ranked second only to 7.6% for Alberta. All this is of course no surprise since Newfoundland was the least developed province in Canada and has experienced the fastest rate of development during the period -- personal disposable income growing at 7.5% per annum, as compared with the national average of 6.4% .

Alberta ranked second in the annual rate of expansion of the telephone industry, possibly as a result of the oil boom in that province since the early fifty's.

Although the rate of growth in local - and toll-telephone services in each province is not the same, it is worthwhile to note that

---

[23] Although Ontario recorded the lowest rate of growth in local-telephone service in Canada, the actual rate should probably be much higher than this recorded 5.7%, if data for Bell Canada were broken down between Ontario and Quebec. See footnote in Table XV.

long-distance services have been uniformly growing faster than local services. This seems to confirm, among other things, the intuitive feeling that toll-telephone services are more income-elastic than local-exchange services.

Conclusions

It is obviously impossible to summarize such quantities of data in any simple descriptions. To understand the significance and the rationale for the trends outlined above, we turn in the next three chapters to separate analyses of three main aspects of the operations of the telecommunications sector. Thus the next chapter links, through an extensive demand analysis, the revenue and output price trends described in Sections 2 and 3 of this present chapter, Chapter IV sets out an analysis of production relating inputs and input prices (discussed in section 3) to factor productivities (presented in section 4), while Chapter V in part completes the circle by relating output and demand to requirements for physical capital formation (described in section 5). (Explanation of the interindustry and inter-regional structure of the sector detailed in sections 6 and 7 above must await a more extensive analysis.) We therefore turn now to an analysis of the determinants of revenue flows to the suppliers of Telecommunications services.

TABLE XV

Rates of Growth in the Telephone Industry

A Regional Comparison
(Percentage Increase)

	Population 1950-1967	Personal Dis. Income 1950-1967	Revenue from Local Service 1950-1967	Revenue from long dis. serv. 1950-1967	Revenue from other sources[1] 1950-1967
NWT & Yukon	3.9	7.2	-	-	-
British Columbia	3.1	6.7	10.4	12.7	7.3
Alberta	3.0	6.6	11.4	13.3	11.9
Saskatchewan	0.9	4.7	5.9	10.1	24.0
Manitoba	1.4	5.5	8.1	12.6	8.6
Ontario	2.7	6.4	5.7*	7.6*	14.5*
Quebec	2.4	6.9	9.5*	10.0*	7.1*
New Brunswick	1.2	5.8	8.5	11.2	18.3
Nova Scotia	1.1	5.6	7.7	10.9	13.1
P. Edward Is.	0.7	6.1	9.0	9.5	11.4
Newfoundland	2.1	7.5	12.6	19.3	10.2
CANADA	2.4	6.4	9.4	10.7	8.6

	Cost of plant 1950-67	salaries[2] and wages 1946-67	Number[3] of employees 1946-67	Number of residence phones 1949-67	Number of business phones 1949-67
NWT & Yukon	-	15.6	-	8.2	8.1
Brit. Columbia	12.7	8.1	1.4	7.0	7.5
Alberta	14.0	13.3	8.3	9.2	7.6
Saskatchewan	10.1	8.9	4.4	5.2	5.5
Manitoba	9.2	8.3	2.5	5.7	5.0
Ontario	-14.8*	6.1	.39	5.6	5.5
Quebec	17.8*	7.8	2.6	7.2	5.9
N. Brunswick	10.2	8.0	2.2	5.6	5.5
Nova Scotia	9.7	7.6	2.3	4.7	5.0
P. Edward Is.	10.6	6.8	1.4	6.0	5.1
Newfoundland	15.0	15.2	8.4	10.9	17.5
CANADA	9.8	10.2	4.5	7.0	6.3

*Includes data of Bell Canada, which operates in Newfoundland, Quebec, Ontario and the Northwest Territories.

[1] Includes revenue from public pay phones
[2] Full-time and part-time employees
[3] Full-time employees only

Source: Computed from data in DBS National Accounts: Income and Expenditure and Telephone Statistics

APPENDIX TO CHAPTER II

TABLE A

Percentage Distribution of Gross Domestic Product at Factor Cost, by Industry - Communication

Year	Percentage
1944	1.3
1945	1.4
1946	1.6
1947	1.6
1948	1.5
1949	1.5
1950	1.6
1951	1.6
1952	1.6
1953	1.7
1954	1.9
1955	1.9
1956	2.0
1957	2.0
1958	2.1
1959	2.2
1960	2.3
1961	2.4
1962	2.4
1963	2.4
1964	2.5
1965	2.5
1966	2.4
1967	2.5

Source: DBS Catalogue Number 13-201 (National Accounts)

1944-56, DBS 13-201 (1926-56)
1955-1962, DBS 13-201 (1962)
1959-1967, DBS 13-201 (1967)

TABLE B

Total Revenues of the
Canadian Telecommunications Sector

(millions of dollars)

Year	The Telephone Industry			The Telegraph and Cable Industry			The Broadcasting Industry			Total Sector	
	revenue in current (undeflated) dollars (1)	revenue in constant (1967) dollars (2)	percentage of total sector revenue in constant dollars (3)	revenue in current (undeflated) dollars (4)	revenue in constant (1967) dollars (5)	percentage of total sector revenue in constant dollars (6)	revenue in current (undeflated) dollars (7)	revenue in constant (1967) dollars (8)	percentage of total sector revenue in constant dollars (9)	Current dollars (10)	Constant (1967) dollar (11)
1950	199			24							
1951	241			29							
1952	279	296		33	46						
1953	311	330		37	51						
1954	341	361		38	52						
1955	376	396		39	53						
1956	422	443	70.5	41	53	8.5	104	132	21.0	567	628
1957	468	490	70.6	45	57	8.2	118	147	21.2	631	694
1958	508	528	70.0	48	59	7.6	140	172	22.4	696	759
1959	582	572	70.0	53	64	7.6	152	184	22.4	787	820
1960	628	612	70.0	59	70	7.8	164	195	22.2	851	877
1961	679	664	70.0	64	76	7.7	181	214	22.3	924	954
1962	733	730	70.0	71	83	7.7	201	235	22.3	1005	1048
1963	787	778	70.0	74	85	7.5	219	251	22.5	1080	1114
1964	860	852	70.2	79	88	7.3	244	273	22.5	1183	1213
1965	948	935	71.2	86	93	6.6	271	293	22.2	1305	1321
1966	1049	1045	71.3	96	99	6.6	310	321	22.0	1455	1465
1967	1164	1164	71.4	105	105	6.5	360	360	22.1	1629	1629
1968	1268			117			372			1757	

Sources:

(1) : DBS 56-203 1950-1968.

(2) : Column (1) deflated by Bell Canada revenue deflators.

(3) : Calculated from columns (2) and (11).

(4) : DBS 56-201 1950-1968.

(5) : Column (4) deflated by GNP deflator.

(6) : Calculated from columns (5) and (11).

(7) : DBS 56-204 1956-1968.

(8) : Column (7) deflated by GNP deflator.

(9) : Calculated from columns (8) and (11).

(10) = (1) + (4) + (7).

(11) = (2) + (5) + (8).

TABLE C

Distribution of Total Revenue of the Telephone Industry*

(percent of total)

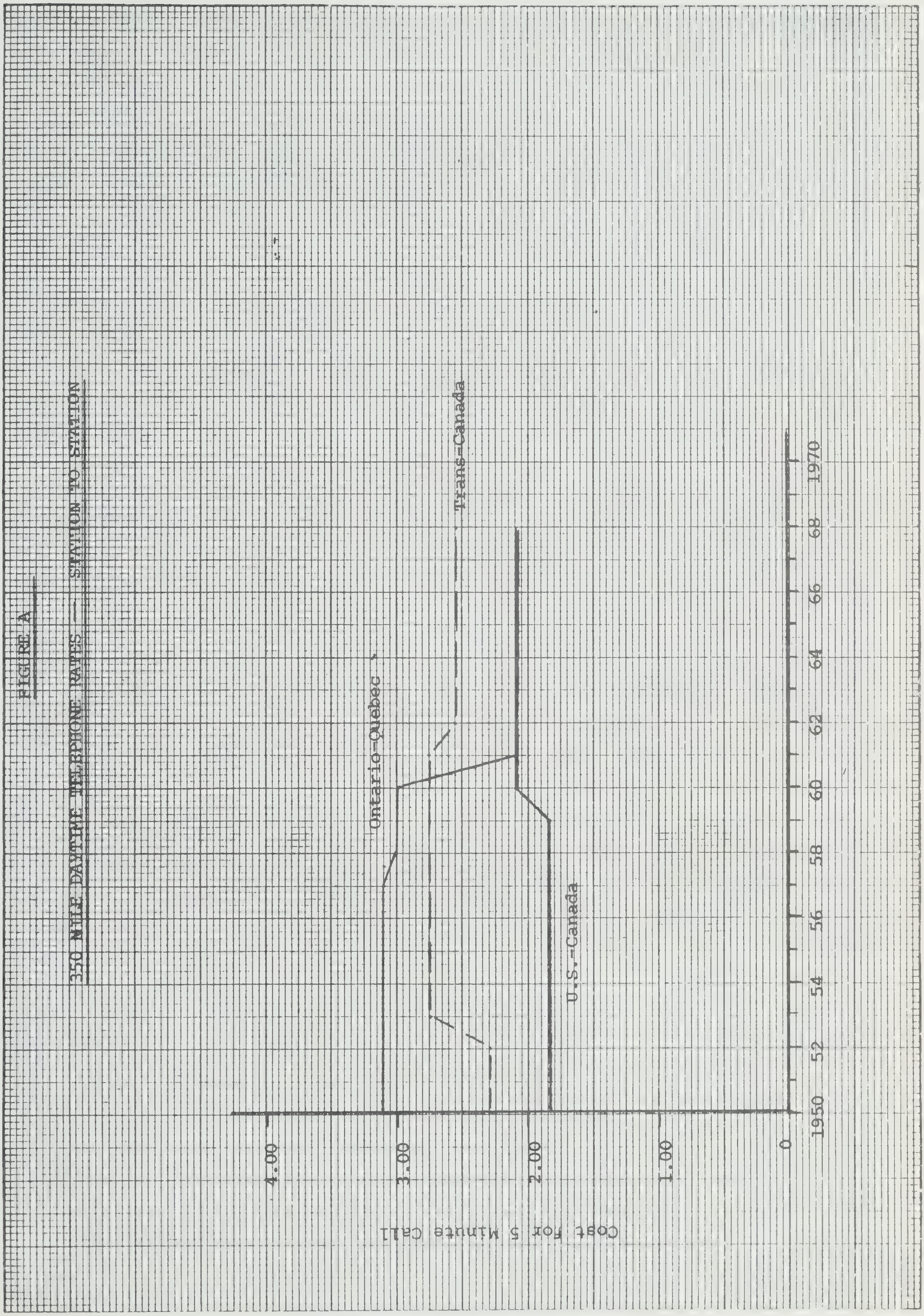
Year	TWX	Telpak	Private Line	Broadcast	Other
1955			.85	.29	98.86
1956			.95	.31	98.74
1957			1.09	.43	98.48
1958			1.28	.75	97.97
1959			1.36	.74	97.90
1960			1.61	.76	97.63
1961			1.91	.75	97.33
1962		.05	2.08	.86	97.00
1963		.27	2.27	.91	96.55
1964		.38	2.36	.86	96.40
1965	.21	.41	2.24	.86	96.28
1966	.24	.48	2.03	.85	96.40
1967	.26	.52	2.06	.92	96.24
1968	.27	.59	2.11	.94	96.10

* Note: no adjustment for price changes has been made.

Sources: Information on TWX, Telpak, Private Line and Broadcasting are obtained from TCTS; total telephone revenue from DBS *Telephone Statistics*

FIGURE A

350 MILE DAYTIME TELEPHONE RATES — STATION TO STATION



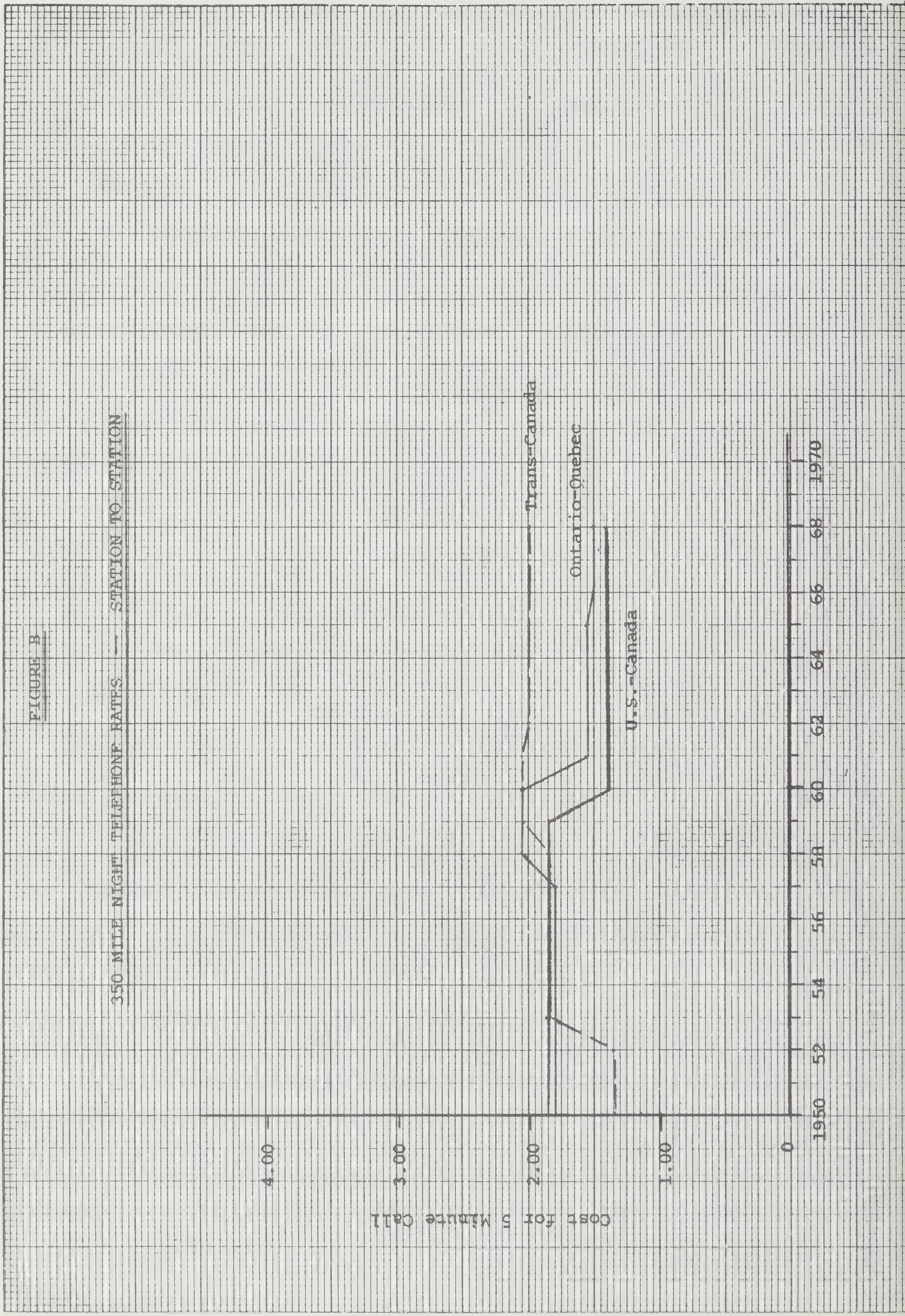


FIGURE B
350 MILE NIGHT TELEPHONE RATES — STATION TO STATION
Trans-Canada
Ontario-Quebec
U.S.-Canada
Cost for 5 Minute Call
4.00
3.00
2.00
1.00
0
1950
52
54
56
58
60
62
64
66
68
1970

FIGURE C

350 MILE DAYTIME TELEPHONE RATES -- PERSON TO PERSON

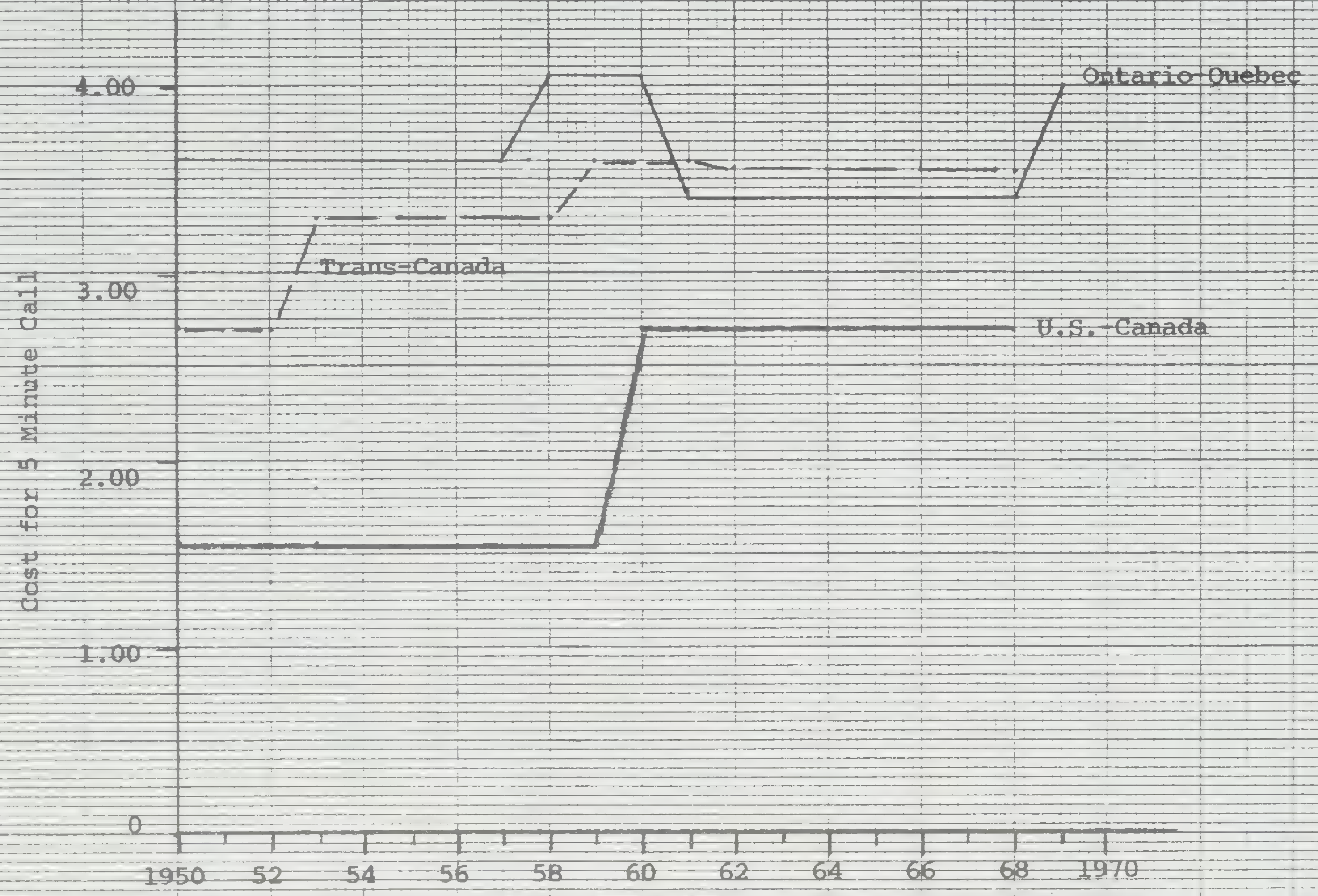


FIGURE D

350 MILE NIGHT TELEPHONE RATES — PERSON TO PERSON

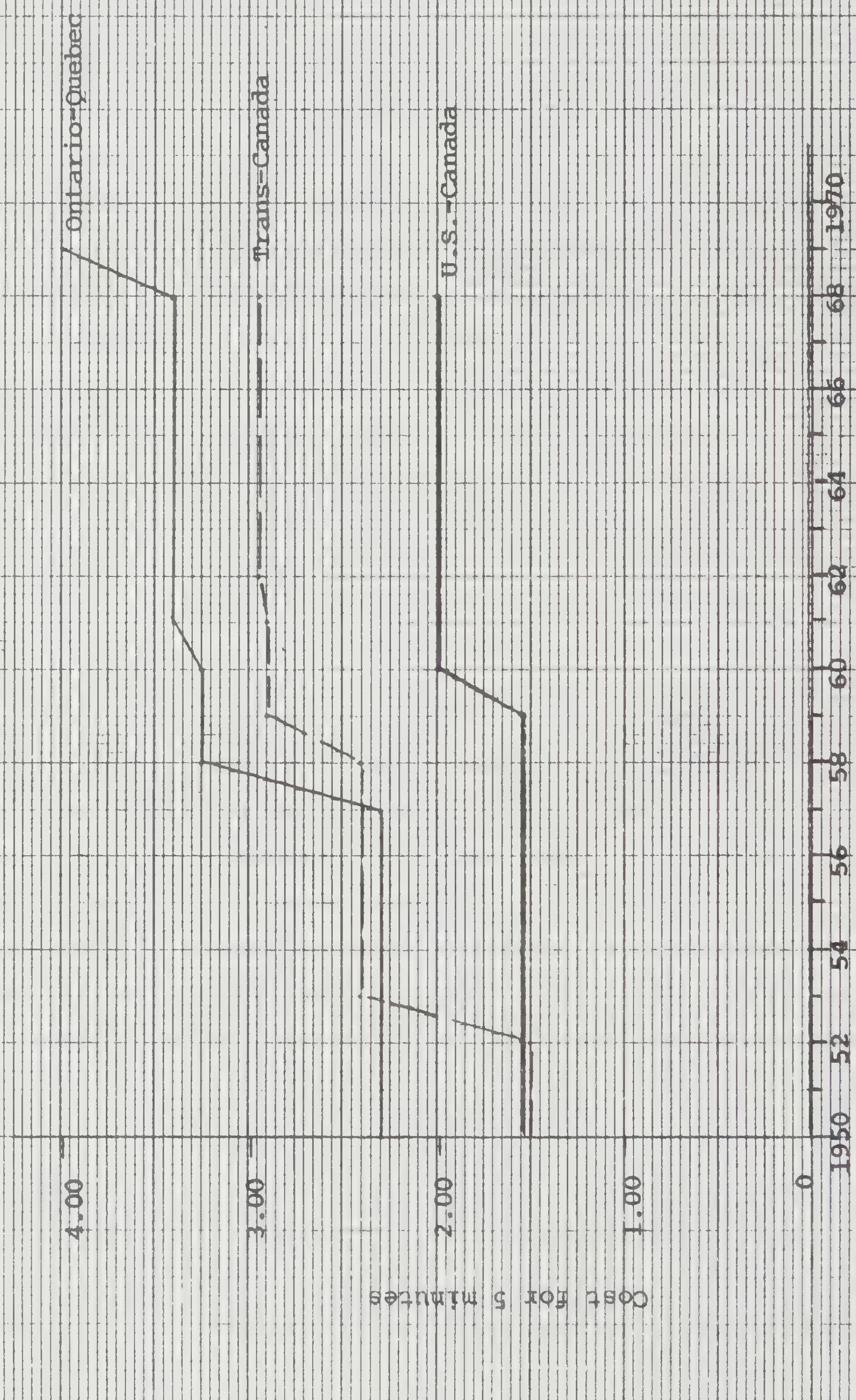


TABLE D

THE INTER-INDUSTRY FLOW OF GOODS & SERVICES
TO COMMUNICATIONS FROM OTHER INDUSTRIES
CANADA 1949

(Producer's Prices)

	Millions of Dollars
Rubber Products	0.9
Textile Products (excluding clothing)	1.0
Furniture	0.6
Wood Products (excluding furniture)	0.2
Paper Products	0.4
Printing, Publishing & Allied Industries	4.5
Iron & Steel Products, n.e.s.	0.3
Transportation Equipment	2.6
Non-ferrous Metal Products, n.e.s.	0.5
Electrical Apparatus & Supplies	6.8
Non-metallic Mineral Products	0.2
Products of Petroleum & Coal	4.1
Chemicals & Allied Products	0.1
Miscellaneous Manufacturing Industries	1.1
Construction	11.9
Transportation, Storage & Trade	22.8
Communication	29.9
Electric Power, Gas & Water Utilities	1.2
Finance, Insurance & Real Estate	5.9
Service Industries	9.1
Unallocated	11.1
Imports of Goods & Services	0.3
Indirect Taxes on Imported Goods & Services	0.1
Indirect Taxes Less Subsidies on Domestic Goods & Services	10.3
Sub-total	126
Wages, Salaries & Supplementary Labor Income	136
Investment Income	35
Capital Consumption Allowances & Validation Adjustments	30
Gross Domestic Product at Factor Cost	201
TOTAL INPUT	327
TOTAL INPUT EXCLUDING INTRA-INDUSTRY CONSUMPTION	297

SOURCE: Supplement to The Inter-Industry Flow of Goods & Services, Canada, 1949, DBS 13-513, Table 1.

TABLE E

THE INTER-INDUSTRY FLOW OF GOODS & SERVICES
FROM COMMUNICATIONS TO OTHER INDUSTRIES
CANADA 1949

(Producer's Prices)

	Millions of Dollars
Agriculture	--
Forestry	--
Fishing, Hunting & Trapping	--
Metal Mining, Smelting & Refining	1.1
Coal Mining, Crude Petroleum & Natural Gas	0.2
Non-metal Mining, Quarrying & Prospecting	0.3
Meat Products	2.3
Dairy Products	2.0
Fish Processing	1.5
Fruit & Vegetable Preparations	0.3
Grain Mill Products	2.5
Bakery Products	2.3
Carbonated Beverages	0.8
Alcoholic Beverages	1.0
Confectionery & Sugar Refining	1.0
Miscellaneous Food Preparations	1.5
Tobacco & Tobacco Products	0.1
Rubber Products	2.2
Leather Products	1.9
Textile Products (excluding clothing)	2.3
Clothing (Textile & Fur)	7.4
Furniture	1.9
Wood Products (exclucing Furniture)	4.7
Paper Products	8.9
Printing, Publishing & Allied Industries	6.3
Primary Iron & Steel	0.7
Agricultural Implements	0.2
Iron & Steel Products, n.e.s.	6.9
Transportation Equipment	3.5
Jewellery & Silverware (incl. watch repair)	0.7
Non-ferrous Metal Products, n.e.s.	0.7
Electrical Apparatus & Supplies	3.9
Non-metallic Mineral Products	0.7
Products of Petroleum & Coal	2.0
Chemicals & Allied Products	4.8
Miscellaneous Manufacturing Industries	2.4
Construction	8.8
Transportation, Storage & Trade	27.8
Communication	29.9
Electric Power, Gas & Water Utilities	0.4
Finance, Insurance & Real Estate	13.0
Service Industries	43.1
Unallocated	--
Total Intermediate Output	202
Personal Expenditure on Consumer Goods & Services	117
Government Expenditure on Goods & Services	8
Total Final Output	125
TOTAL OUTPUT	327

SOURCE: Supplement to The Inter-Industry Flow of Goods & Services, Canada, 1949, DBS 13-513, Table 1

III. The Demand for Telephone and Telegraph Services

I. Introduction

The preceding chapter approached the historical record of the telecommunications industry primarily with the purpose of description. Beginning with this chapter we approach the historical record with another purpose in mind, namely, what can it tell us about how the telecommunications industry is likely to evolve in the future? This chapter and the two following focus on the telephone and telegraph sectors -- this chapter on the demand for telephone and telegraph services, Chapter IV on the production and technological characteristics of the sectors, and Chapter V on the determinants of their investment in new plant and equipment. Chapters VI and VII then take up similar questions with regard to broadcasting and the manufacture of telecommunications equipment. Finally, Chapters VIII and IX pull the separate pieces together, attempting projections of the major variables to 1980, and summarizing the main conclusions of the study.

II. The Determinants of Demand for Telephone and Telegraph Services

The primary determinants of expenditures for telephone and telegraph services are income, relative prices, population, and technology. The first three operate directly on demand, while technology has a dual impact: on the supply side through cost reduction and the availability of new services, and on the demand side through pressure for provision of new services. Projection of expenditures for telecommunications thus requires

that we have quantitative estimates of the effects of changes in these factors. In particular, we need to know:

1. The income elasticity of demand;
2. The price elasticity of demand;
3. The future growth of population;
4. The future course of technology.

Of the four, it is clear that predicting the future course of technology is the most problematic. Income and price elasticities can be estimated with some confidence from past behaviour, and the Dominion Bureau of Statistics has developed sophisticated techniques for extrapolation of the population. Technology, however, presents a problem of entirely different magnitude. As noted above, technology has a twofold impact on the supply side of the market through reduction of the costs of providing old services and the introduction of new ones. It is the new services that create the difficulty. Cost reductions, which in some cases can be foreseen with clarity, ordinarily lead to lower prices, and can therefore be incorporated into the analysis through that device, but new services, by their very nature, have no past history on which to build. Even for those services now on the horizon, such as "phonovision", it is virtually impossible for us to forecast in quantitative terms what the consuming public's reaction to them will be; for those not in the pipeline, it is obviously impossible to say anything.

As a result, apart from being able to translate cost reductions (which themselves must come from technical sources) into lower prices, there is little that economic analysis can say about the future

impact of technology on demand, and therefore technology has been put to the side in the analyses which follow.[1] Nevertheless, before leaving the subject, several observations are in order.

First, in terms of broad magnitudes, it would be surprising if the introduction of new services were to lead to a major revamping of the way in which consumers allocate their expenditures among broadly defined categories. For example, it is unlikely that phonovision will lead to an increase in expenditures for the category "communication services", at the expense of expenditures for food, transportation, or other equally broad categories (although it is conceivable that intercity travel and certain recreation expenditures could be adversely affected). What is more likely is that phonovision will lead to a reallocation of expenditures within "communication expenditures" itself. Also, it should be remembered that communications is not the only category of consumer expenditure that is likely to be introducing new products and services in the years ahead. Competition for the consumer's dollar is always keen, and there is no reason _a priori_ to assume that new communications services will fare any better (or any worse, for that matter), than the new products of any other industry.

Second, long lead times and lags in installation of new devices, as well as inertia in consumers' adaptation to new products, are on our side. For example, the following extract from a letter dated June 17, 1970 to shareholders of AT & T suggests the pace at which diffusion of new products such as "phonovision" might occur:

---

[1] Historical technological change and its impact on the provision of telecommunications services is dealt with in the next chapter.

> Bell Telephone Company of Pennsylvania has announced plans to make the world's first offer of Picturephone service for home and office use in that area [Pittsburgh] on July 1.
>
> Picturephone service will soon be introduced in other major cities around the country. By 1975, it is anticipated that 100,000 Picturephone sets will be in operation in two dozen cities. And by 1980, it is expected that the service will be widespread with perhaps a million sets in service.

Unfortunately, however, when we turn to consider industrial users, this somewhat sanguine appraisal of the effect of new services on the demand for telecommunications must give way to doubt. The advent of remote-access high-speed computation has provided an entirely new dimension in the business and industrial use of the telecommunications system. Data transmission has grown dramatically in recent years, and at present this growth shows no signs of slackening. However, since data transmission on a large scale is such a recent phenomenon, projecting its future growth is a hazardous enterprise. The historical record is too short for regression-based projection, and because of the rapid growth on a small base, to extrapolate mechanically the rate of growth for the few years for which data are available would probably be seriously misleading. The proper procedure would be to integrate the demand for data transmission into a study of the computing industry, but such a study, which would itself be a major undertaking, is outside our present terms of reference. Nevertheless, we shall return briefly to this problem at the end of this chapter and again in Chapter IX.

III. Data

Our major source of data for the telephone and telegraph industries has been the Dominion Bureau of Statistics yearly publications, Telephone Statistics (Catalogue Number 56-203) and Telegraph and Cable Statistics (Catalogue Number 56-201). In addition to the DBS publications, we have also utilized data made available to us, much of it on a confidential basis, by Bell Canada and Canadian National/Canadian Pacific Telecommunications. A final source was the unpublished paper of R.E. Olley (1970), which itself employed data made available by Bell Canada.

As we discussed in Chapter II, the difficulties involved in defining output in terms of a physical unit based on the number of messages, their duration, and distance necessitate using price-deflated revenue as the measure of output. For the telephone companies, the following categories of revenue have been analyzed:

1. DBS data
    - Aggregate Canada
        - total revenue
        - local-service revenue
        - long-distance revenue
    - Canada by region
        - total revenue

2. Bell Canada data
    - total revenue
    - total residence revenue
    - total business revenue
    - residence local-service revenue

residence long-distance revenues

business local-service revenues

business long-distance revenues,

while for the telegraph and cable companies, the revenue categories analyzed have been:

1. DBS data

total industry revenue

public and government message service revenues

revenues from 'leased circuits'

revenue from 'other leased plant'

total leasing revenue

total'transmission'revenue

2. CN/CP data

total CN/CP revenue

revenues from public message services, cables and money orders

telex revenues

revenues from program broadcast transmission

revenues from private wire leasing and equipment rentals.

For comparison with telegraph and cable statistics, the revenues from the following closely related telephone services were also studied:

3. TCTS data

revenues from TWX and private wire leasing

revenues from program broadcast transmission.

The price indices used to deflate the telephone revenue series have been obtained from two sources: the DBS and total Bell Canada series have been deflated by the deflators for Bell Canada revenues which are given in the Olley paper, while the Bell Canada local- and long-distance revenue series have been deflated by price indices constructed from historical rate schedules filed with the CTC and made available to us by Bell Canada. Descriptions of these indices are given later in this chapter, as are also descriptions of price indices for telegraph and cable.

IV. Models Employed in the Analysis

In investigating the determinants of the demand for telephone and telegraph, practical considerations have necessarily guided our efforts, and we have resisted the temptation to experiment with novel ideas which under more relaxed circumstances might have proven helpful. Accordingly, we have relied upon the standard methods and techniques of demand analysis. In particular, we have made extensive use of the dynamic model of demand developed by Houthakker and Taylor in their study of consumer demand in the United States (1966). This model has been the point of departure in all of the categories of revenue analyzed, and there are only a few instances where it (or one of its variants) has failed to give plausible results.

Since a detailed derivation of the Houthakker-Taylor model is more involved technically than we care to become in the body of this report, we shall only sketch its general features here; full particulars can be found in the appendix to this chapter. The estimating equation of the Houthakker-Taylor model takes the form:

(1) $q_t = A_0 + A_1 q_{t-1} + A_2 \Delta x_t + A_3 x_{t-1} + A_4 \Delta p_t + A_5 p_{t-1}$,

where

q = quantity purchased, measured in real terms

x = income, also measured in real terms

p = the relative price of the good

$\Delta x_t = x_t - x_{t-1}$

$\Delta p_t = p_t - p_{t-1}$

and $A_0, \ldots, A_5$ are coefficients to be estimated. This model is based on an underlying stock-adjustment mechanism which sees the consumer as attempting to bring his stocks into a desired relationship with his income and the level of prices. We distinguish between two cases, depending upon the type of good involved. If the good is a durable good, these stocks will have a concrete interpretation as a physical inventory. With automobiles, for example, they will consist of the existing (depreciated) inventory of autos. This is the usual case of stock adjustment behaviour, where we expect existing inventories to have a depressing effect on current purchases. On the other hand, if the good is one for which inventories of any quantity are normally of no consequence, the stocks take on a psychological dimension and, rather than acting as a brake on current purchase, they may tend actually to encourage it. This is the case of habit formation, a particularly good example of which is the consumption of tobacco: the more that an individual has smoked in the recent past, the more, everying else remaining constant, we should expect him to smoke now. We should also expect this behaviour to characterize the consumption of telecommunications services.

One of the key features of the Houthakker-Taylor model is that it allows one to distinguish between the effect on consumption resulting from a change in income or relative price before stocks have a chance to adjust and the effect after they have adjusted fully to the new level of income or price . The former is referred to as the short-run effect, while the latter is referred to as the long-run effect. In the case of a good subject to stock adjustment, the short-run effect will be greater than the long-run effect, but the opposite will be true with a good subject to habit formation. Indeed, when habit formation is strong, there may be scarcely any short-run response at all. The short-run reaction coefficients are associated primarily with the coefficients of Δx_t and Δp_t in equation (1), while the long-run coefficients are associated with the coefficients of q_{t-1}, x_{t-1}, and p_{t-1}. Those wishing more information on the decisions of this analysis may find it in the appendix to this chapter.

In some instances, we have used the alternative dynamic model formulated by Houthakker and Taylor, whose estimating equation takes the form:

$$(2) \quad q_t = A^*_0 + A^*_1 q_{t-1} + A^*_2(x_t + x_{t-1}) + A^*_3(p_t + p_{t-1}) ,$$

where q, x, and p all have the same interpretation as in equation (1). In contrast to the first model, which views the consumer as attempting to bring his <u>stocks</u> into a desired relationship with income and prices, this model sees him as doing this with regard to the <u>flow</u>. Accordingly, we shall refer to this model as the <u>flow-adjustment model</u>, and to the first model as the <u>stock-adjustment model</u>. Use of the flow-adjustment model is

suggested when the coefficients A_3 and A_5 in equation (1) are large relative to A_2 and A_4.

V. Empirical Results 1: Telephone

1. DBS data: total Canada

Total Revenue

The first category analyzed is the total revenue of all telephone companies in the country. This category refers to combined revenue from all sources, which means that revenues from directory advertising are included in addition to those from normal telecommunications activity.[2] Since DBS does not publish deflators for the revenue data that it collects, it has been necessary to deflate by an implicit deflator for the total revenue of Bell Canada.[3] However, given the importance of Bell's revenues in the total for the industry, the error introduced by this procedure <u>should</u> be of little consequence.[4] For the income variable, we have used GNP measured in constant (1967) dollars, and for the relative price we have used the Bell deflator divided by the implicit deflator for GNP. The data are annual and cover the period 1952 through 1967. Ordinary least squares

---

[2] Strictly speaking, advertising revenues should be netted out of total revenue, but since DBS does not break out advertising revenues separately this cannot be done. The closest that one can come would be to use the sum of local-service and long-distance revenues, but this would purge too much. Excluded would be revenues generated by leased lines, and these should clearly be part of total revenue. For this reason, we elected to use total revenue from all sources. Since directory advertising probably moves closely with local revenues the error involved should be small.

[3] See Olley (1970).

[4] Unfortunately, the results for Bell Canada below suggest that this may not be the case.

estimation has been employed, not only for this category, but throughout the entire report.

The equation estimated is as follows (t-ratios are in parentheses):[5]

$$(3) \quad \underset{}{q_t} = \underset{(1.28)}{303.21} + \underset{(6.54)}{.9176}\, q_{t-1} + \underset{(.70)}{.00131}(x_t + x_{t-1}) - \underset{(-1.98)}{1.3313}\,(p_t + p_{t-1})$$

$R^2 = .999$ $\quad S_e = 8.89$ $\quad DW = 1.78$

elasticities calculated at 1967 levels

income	1.77
relative price	-2.78

q = total telephone company revenue (in millions)/implicit deflator for total revenue of Bell Canada

x = GNP in millions of 1967 dollars

p = implicit deflator for total revenue of Bell Canada/ implicit deflator for GNP (1967 = 100).

This is an instance of the flow-adjustment model. The items worthy of note in the equation are the substantial income and price elasticities -- both are considerably greater than unity (in absolute value) -- the high R^2, and the absence of autocorrelation in the residuals (as evidenced by a value of 1.78 for the Durbin-Watson coefficient). Despite the tight fit, however, the income and price coefficients are not as significant statistically as one would like. The t-value for income is less than one, while that for the relative price barely borders on two. This equation was selected in preference to one based on the stock adjustment model because of an implausibly large long-run price elasticity with the latter; otherwise, the two models give essentially the same results.

5 The elasticities reported for the flow-adjustment model are long-run elasticities.

Despite the fact that the income coefficient is insignificant by conventional statistical standards, the implied income elasticity of 1.8 seems reasonable. However, since a substantial part of total revenue consists of revenues from local service -- which we should expect to be relatively independent of price -- a price elasticity of -2.8 may be too high. The reasons for holding this view will become clear in a moment, but here we should note a technical reason as to why our procedure might over-estimate the price elasticity. The constant-dollar revenue series is obtained by a deflator that forms the numerator of the relative price. If for some year (or years) this deflator is too low, our measure of constant-dollar revenue for that year will be too high, and the regression will tend to attribute this high expenditure to the (incorrectly) low price. And the same bias will operate on the other side if the deflator for some years is too high. Thus, the high price elasticity in equation (3) may reflect simply the way in which constant dollar revenue has been derived.[6]

In addition to equation (3), an equation has also been estimated with revenue and income expressed in per-capita terms. The reason for doing this is to see how much the aggregate income elasticity is influenced by population growth. This is important information to know, for if the rate of growth of the population should taper off, projections based on equation (3) could be seriously biased. Since equation (3) is estimated with aggregate revenue and aggregate income, the income elasticity reflects an amalgam of population growth and higher income per head. If the individual income elasticity were unity, then whether the variables were in aggregate or per-capita terms would not matter, but when the

---

[6] Of course, only when errors in measurement of the price variable are large will this bias be significant. In the absence of such errors, our procedure entails no such bias.

individual elasticity is greater than unity -- as is the case with expenditures for telephone services -- it does matter. If the goal is to estimate an elasticity applicable to a single individual, population growth will lead to an elasticity estimated from aggregate data which is biased toward unity.

The results from applying the stock-adjustment model to total revenue per capita follow:

$$q_t = \underset{(.64)}{6.50} + \underset{(19.34)}{.9232}\, q_{t-1} + \underset{(1.77)}{.00339}x_t - \underset{(-1.62)}{.0882}\, p_t \qquad (4)$$

$R^2 = .999 \qquad S_e = .40 \qquad DW = 1.76$

Elasticities (computed at 1967 levels)

	income	relative price
Short run	.10	-.08
Long run	2.48	-2.01

q = total telephone revenue per capita/implicit deflator for total revenue of Bell Canada

x = GNP per capita in 1967 dollars

p = implicit deflator for total revenue of Bell Canada/implicit deflator for GNP (1967 = 100).

Since this is the first equation presented using the stock-adjustment model, it will be useful to discuss it in some detail. First, it should be noted that the equation is actually a special case of the model, for it has been estimated under the restriction that A_2 and A_4 are equal, respectively, to A_3 and A_5. This form of the model implies a substantial element of habit formation, a fact evidenced in income and price elasticities which are large in the long run, but nearly

zero in the short run. This property reflects the strong inertia characteristic of the demand for services. The statistical qualities of this equation parallel those for the aggregate equation. The coefficients have the correct sign, the fit is very good, and autocorrelation is absent from the residuals.[7/] Income is somewhat more significant statistically and the relative price somewhat less so, but once again neither has a t-value greater than two. The long-run income elasticity of 2.5 is well in excess of its value in the aggregate equation, which confirms the observation just made. On the other hand, the long-run price elasticity is lower than in the aggregate equation, but at -2.0 may still be too high.

Local-service revenues

The second DBS telephone revenue category analyzed is revenues from local service. As with total revenue, the data refer to the combined revenue from local service of every telephone company in the country. The data have been deflated with the implicit local-service deflator for Bell Canada, and this variable also forms the numerator of the relative price. Once again, the time period covered is 1952-67. The empirical results follow.

$$(5)\quad \underset{(108.04)}{q_t = 21.76} \;+\; \underset{(10.19)}{.9129\, q_{t-1}} \;+\; \underset{(1.23)}{.00088\,(x_t + x_{t-1})} \;-\; \underset{(-.59)}{.1876\,(p_t + p_{t-1})}$$

$$R^2 = .999 \qquad S_e = 2.98 \qquad DW = 1.87$$

elasticities (computed at 1967 levels)

income 2.16

relative price -.70

7/ It should be kept in mind, however, that in models with the lagged dependent variable as a predictor the Durbin-Watson coefficient is biased toward 2.

q = total local service telephone revenue (in millions)/ implicit deflator for local service revenues of Bell Canada

x = GNP in millions of 1967 dollars

p = implicit deflator for local service revenues of Bell Canada/ implicit deflator for GNP (1967 = 100).

Since local service accounts for more than 50% of total telephone revenue, we should expect the local-service results not to stray too far from those for total revenue, and we see that this is the case. The flow-adjustment model gives the best results, the fit is extraordinarily tight, the residuals are free of autocorrelation, and the income elasticity, though of only marginal statistical importance, is large. There is a major difference with regard to the importance of the relative price, but this is hardly surprising. On the part of households, local-service revenues should be determined primarily by the number of families and the level of personal disposable income, while on the part of businesses the general level of economic activity should be the primary determining factor. In neither case should we expect local-service rates to play much of a role. Thus, a less-than-unity price elasticity for local-service revenues is what we should expect.

Indeed, since local-service revenues are derived from the rental on telephones installed, at leasing rates established by regulation, one should expect to be able to explain local revenues simply by explaining the number of telephones installed. Unfortunately, matters are complicated by the presence of different rentals for various classes of business and residence installations, extension phones, and special features. For this reason we have not pursued this approach here, although we have convinced

ourselves that the number of residence main telephones can be well explained by population growth and per-capita income levels (which of course also reflects a process of general urbanization and the near-saturation of the household market so far as telephone installations are concerned).[8] Adding an equation for business telephone installations based upon business product, one would expect to account for the bulk of local revenues without any significant price dependence. Adding the fringe and premium items such as extension phones and special features undoubtedly does introduce a measure -- possibly very strong -- of price dependence, and these categories should be explored in isolation. Unfortunately we have had to leave this undertaking for the future.

Long-distance revenue

For long-distance revenues, the same form of the stock-adjustment model as was used for total revenue per-capita -- A_3 equal to A_2 and A_5 equal to A_4 -- has been found to yield the best results. The equation is as follows:

$$q_t = \underset{(.93)}{112.15} + \underset{(6.21)}{.9200}q_{t-1} + \underset{(.79)}{.00104}\, x_t - \underset{(-1.36)}{.9478}\, p_t \tag{6}$$

$$R^2 = .997 \qquad S_e = 6.82 \qquad DW = 1.91$$

---

[8] The equation is $q_t = -.82 + .9171\, q_{t-1} + 2.2474\Delta x_t + 1.7237\, x_{t-1}$

$$R^2 = .9997 \qquad S_e = .10 \qquad DW = 2.45$$

where

q = total telephones per 100 persons

x = GNP per-capita in 1967 dollars .

elasticities (calculated at 1967 levels)

	income	relative price
Short run	.08	- .11
Long run	1.90	-2.57

q = total long-distance telephone revenue (in millions)/ implicit deflator for long-distance revenues of Bell Canada

x = GNP in millions of 1967 dollars

p = implicit deflator for long-distance revenues of Bell Canada/implicit deflator for GNP (1967 = 100).

Apart from income and relative price not being as significant statistically as one would prefer, this equation presents a highly plausible picture of the demand for long-distance telephone. Habit formation is strong and, in contrast to local-service revenues, there is a sharp long-run response of demand to a change in price. The long-run elasticity with respect to income is also large, and this, too, we should expect. In keeping with the general results of this section, the equation fits the historical data extremely well, and once again there is no problem of autocorrelated residuals.

2. DBS Data: Canada by Region

In a country as geographically and economically diverse as Canada, there might be some question as to whether the demand functions estimated in the preceding section and intended to apply to the country as a whole are also applicable to the separate regions of the country in isolation. Since DBS provides a breakdown of its telephone revenue data by province,

it is reasonably straightforward to test whether this is the case. To this end, we have divided the country into four regions, namely:

1. The Maritime provinces
2. Ontario and Quebec
3. The Prairie Provinces
4. British Columbia and the Yukon Territory.

These regions will be identified by the suffixes a(Atlantic), c(Central), w(Western) and p(Pacific).

Since population varies widely across regions, the equations have been estimated in per-capita terms and, since the primary purpose of the analysis is to test for regional differences, only total revenue has been analyzed. For income we have had to use personal disposable income instead of GNP as we would prefer since DBS does not publish estimates of GNP by province.[9] For deflators, the revenue data, as before, have been deflated with the deflator for Bell Canada, and personal disposable income has been deflated with the implicit deflator for personal consumption expenditures. The relative price, however, has the GNP deflator in the denominator. Using common deflators ignores, of course, the fact that price trends have probably varied among regions, but since regional deflators do not exist there was no alternative. Once again, the period covered is 1952-67.

---

[9] Data on personal disposable income by Province are unrevised; DBS has published revised estimates of these data, and re-estimation of the regional equations using the revised series would now be possible. Unfortunately, however, lack of time has precluded our undertaking this re-estimation.

The equations for the four regions separately and the four regions combined using the stock-adjustment model (with A_3 and A_5 equal, respectively, to A_2 and A_4) follow:

$$(7)\quad \underset{}{q_{at}} = \underset{(1.10)}{15.54} + \underset{(3.43)}{.6646}\, q_{a(t-1)} + \underset{(1.57)}{.0114}\, x_{at} - \underset{(-2.02)}{.1743}\, p_t$$

$$R^2 = .995 \qquad S_e = .66 \qquad DW = 1.67$$

$$(8)\quad q_{ct} = \underset{(.85)}{9.93} - \underset{(13.70)}{.9313}\, q_{c(t-1)} + \underset{(.87)}{.00371}\, x_{ct} - \underset{(-1.65)}{.0961}\, p_t$$

$$R^2 = .999 \qquad S_e = .46 \qquad DW = 2.55$$

$$(9)\quad q_{wt} = \underset{(2.13)}{31.90} + \underset{(10.97)}{.9822}\, q_{w(t-1)} - \underset{(-.21)}{.00057}\, x_{wt} - \underset{(-2.36)}{.2359}\, p_t$$

$$R^2 = .9996 \qquad S_e = .83 \qquad DW = 1.50$$

$$(10)\quad q_{pt} = \underset{(-1.37)}{-46.35} + \underset{(8.87)}{.9379}\, q_{p(t-1)} + \underset{(2.07)}{.0162}\, x_{pt} + \underset{(.95)}{.1719}\, p_t$$

$$R^2 = .992 \qquad S_e = 1.23 \qquad DW = 2.28$$

$$(11)\quad q_t = \underset{(22.33)}{.9327}\, q_{t-1} + \underset{(1.91)}{.00408}\, x_t - \underset{(-2.27)}{.1170}\, p_t + \underset{(1.54)}{12.20}\, D_a + \underset{(1.31)}{11.72}\, D_c + \underset{(1.31)}{11.48}\, D_w + \underset{(1.22)}{11.29}\, D_p$$

$$R^2 = .996 \qquad S_e = .90 \qquad DW = 1.95$$

elasticities (calculated at 1967 levels)

	income		relative price	
	SR	LR	SR	LR
(7)	.27	1.35	-.27	-1.35
(8)	.07	1.88	-.08	-2.35
(9)	-.009	-.91	-.22	-23.09
(10)	.30	9.24	.14	4.35
(11)	.10	2.88	-.11	-3.04

q = total telephone revenue per capita/implicit deflator for total revenue of Bell Canada

x = personal disposable income per capita in 1967 dollars

p = implicit deflator for total revenue of Bell Canada/ implicit deflator for GNP (1967 = 100)

D_a = dummy variable for Atlantic Region

D_c = dummy variable for Central Region

D_w = dummy variable for Western Region

D_p = dummy variable for Pacific region.

Looking first at the equations for the individual regions [equations (7)-(10)], we see that the ones for Atlantic and Central are quite in keeping with what we have by now come to expect, while the ones for Western and Pacific have their problems. The Western and Pacific equations each have a wrong sign -- income for Western and price for Pacific -- and each has an implausibly high long-run elasticity -- price for Western and income for Pacific. Given the high R^2's, these problems may well be due

to high intercorrelations among the independent variables, especially for Pacific. With Western, the problems with regard to income probably result from the fluctuations in disposable income caused by sharp, short-term swings in farm income. For this region, some measure of permanent income would be preferable. The Atlantic and Central equations, on the other hand, do not present any apparent anomalies. The long-run price elasticity for Central may be a bit high, but this, it will be recalled, is in keeping with the results obtained with the data for Canada as a whole (cf. equation (3)).

To test the hypothesis that the demand for telephone services is homogeneous among regions, we make use of equation (11) which is estimated with the data from all four regions pooled. It will be noted that four dummy variables -- one for each region -- have been included in this equation in order to take into account regional peculiarities (such as industrial structure) which for the most part are unrelated to population. The hypothesis is tested by means of an F-test performed on the reduction in residual variance in going from the "total" equation (equation (11)) to the group of "individual" equations [equations (7)-(10)]. This involves an analysis of covariance as set out in the following table.

Analysis of Covariance

Individual Regression	Sum of Squared Residuals	Degrees of Freedom
(7)	4.79	11
(8)	2.30	11
(9)	7.59	11
(10)	16.75	11
Total	31.43	44
Total regression [(11)]	42.83	53
Reduction in SSR due to different regressions	11.38	9

$$F = \frac{11.38}{9} \Big/ \frac{42.83}{53} = \frac{1.26}{.81} = 1.56$$

$$F_{.10}(9,53) \simeq 1.90$$

Since the calculated F ratio of 1.56 is well below the 10 percent cutoff for 9 and 53 degrees of freedom ($\simeq$ 1.90), we cannot reject the hypothesis that the demand for telephone services is homogeneous among regions.

3. Bell Canada data

On the basis of data made available to us by Bell Canada, we have been able to extend our analysis considerably beyond that possible with the DBS data. Bell provided a breakdown of its revenues between residence and business and a further breakdown within each of these categories between local service and long distance. Such detail is especially useful for, in addition to the difference in demand for local service and for long distance, there are almost certainly differences in the demand for each of

these services between businesses and households. In particular, we should not be surprised to find that the substantial long-run price elasticity for long distance is accounted for by households rather than by businesses.

Unfortunately, the Olley memorandum, from which we obtained the Bell Canada price deflators used up till now, does not provide separate deflators for business and residence revenues, and so, rather than using the same deflator for both, we have constructed our own on the basis of historical rate schedules filed with the CTC and made available to us by Bell Canada. For local service, the residence price index is based on the monthly rate for a two-party line in cities of over 250,000 and the business price index is based on the monthly rate for an individual line, also in cities of over 250,000. For long distance, the residence price index is based on the nighttime station-to-station rate beginning at 6 p.m. for a 3-minute 350 mile call,[10] while the business price index is based on the daytime station-to-station rate for the same distance.

Since Bell Canada operates primarily in the most densely-populated areas of Ontario and Quebec, the income variables must reflect the income level of these two provinces. For households, the income measure should be personal disposable income, which we have, but for businesses the measure ought to be GNP (or better still, gross business product). However, as noted above, DBS does not publish GNP by province, and so we have had to use personal disposable income in the business equations also. With one exception, the equations which follow are based on data covering the

---

[10] To avoid difficulties with the introduction of different rate classes beginning at different times through the night, we computed the rate for a call placed at 7 p.m.

period 1950-67; the exception is the equation for total revenue of Bell, which is based on data for 1952-67. Finally, the residence equations are estimated in per-capita terms.

Residence local-service revenues

(12) $$q_t = -.39 + .9494\, q_{t-1} + .000424\, (x_t + x_{t-1})$$

$$(-.77) \qquad (20.28) \qquad (1.47)$$

$$R^2 = .999 \qquad S_e = .10 \qquad DW = 1.68$$

income elasticity (computed at 1967 levels); 2.38

q = residence local-service revenues of Bell per-capita/ local-service price index for residences (1967 = 100)

x = personal disposable income per-capita for Ontario and Quebec in 1967 dollars.

The important finding for this category is the absence of relative price as an explanatory factor. When price was included in the model, its sign was correct, but t-values on all coefficients in the equation, with the exception of the one for q_{t-1}, were less than one, and when price was tried by itself, its sign became positive (though not significantly so). Consequently, the relative price was excluded and income retained instead. The rather high income elasticity probably reflects the increased use of extension phones and individual (or two-party lines) which accompanies an increase in income.

Residence long-distance revenue

$$(13) \qquad q_t = .24 + .8674\, q_{t-1} + .00117 \Delta x_t + .00103\, x_{t-1} - .-248 \Delta p_t - .00927\, p_{t-1}$$
$$(.14) \quad (2.77) \qquad (1.02) \qquad (.65) \qquad (-4.04) \quad (-1.01)$$

$R^2 = .993 \qquad S_e = .15 \qquad DW = 1.95$

elasticities (calculated at 1967 levels)

	income	relative price
SR	.20	- .37
LR	1.27	-2.33

q = residence long-distance revenues of Bell per-capita/long-distance price index for residences (1967 = 100)

x = personal disposable income per capita for Ontario and Quebec in 1967 dollars

p = long-distance price index for residences/implicit deflator for personal consumption expenditure (1967 = 100).

In contrast to local service, the household demand for long-distance service is seen to be quite sensitive to price, for not only is the relative price an important predictor statistically, but its (long-run) elasticity is well in excess of two (in absolute value). The response of long-distance demand to a change in income is also elastic in the long-run (i.e. the long-run elasticity is greater than one), but not as decidedly so as the demand for local service. Apart from the barely significant income coefficient, the statistical aspects of this equation are quite good. The fit is tight, and the residuals are free of autocorrelation.

Total residence revenue

(14) $$q_t = 2.96 + .8641\, q_{t-1} + .00232\, x_t - .353\, p_t$$
$$(.74) \quad (7.95) \quad (1.10) \quad (-1.87)$$

$R^2 = .996$ $S_e = .27$ DW = 2.13

elasticities (calculated at 1967 levels)

	income	relative price
SR	.12	-.09
LR	1.63	-1.19

q = total residence revenue of Bell per capita/price index for residential telephone service (1967 = 100) [11/]

x = personal disposable income per capita for Ontario and Quebec in 1967 dollars

p = price index for residential telephone service/implicit deflator for personal consumption expenditure (1967 = 100).

We should expect the results for total residence revenue to lie intermediate between those for local service and those for long distance, and this is clearly the case. Perhaps the most relevant finding with this equation is that the price effect for long-distance calls is of sufficient strength to make the household demand for telephone services, local and long-distance combined, slightly elastic (in the long run) with respect to price.

[11/] Constructed as $.675\, p_{ls} + .325\, p_{ld}$ where ls and ld refer to local service and long distance, respectively, and where the weights are an average of the initial and final shares of each revenue category in total residence revenue.

Business local-service revenues

$$(15) \quad q_t = \underset{(-4.09)}{-29.72} + \underset{(6.64)}{.6787}\, q_{t-1} + \underset{(4.00)}{.00236}\,(x_t + x_{t-1})$$

$R^2 = .999 \qquad S_e = 2.35 \qquad DW = 1.50$

income elasticity (calculated at 1967 levels): 1.55

q = business local-service revenues of Bell Canada (in millions)/ price index for business local service

x = personal disposable income for Ontario and Quebec in millions of 1967 dollars

We see that, as with residences, business demand for local service is indicated to be independent of price. This is, of course, a sensible result, and is one which telephone companies have long taken into account in setting local-service rates for businesses _vis-a-vis_ those for households. Despite a hint of positive autocorrelation in the residuals (as indicated by the Durbin-Watson coefficient of 1.50), the statistical quality of this equation is very good. All coefficients are multiples of their standard errors, and, as usual with these data, the R^2 is very high.

Business long-distance revenues

$$(16) \quad q_t = \underset{(-1.47)}{-22.75} + \underset{(5.74)}{.8708}\, q_{t-1} + \underset{(1.59)}{.00213}\, x_t$$

$R^2 = .990 \qquad S_e = 5.01 \qquad DW = 2.37$

income elasticities (calculated at 1967 levels)

SR	.19
LR	2.76

q = business long-distance revenues of Bell Canada (in millions)/price index for business long-distance calls

x = personal disposable income for Ontario and Quebec in millions of 1967 dollars

At first glance, this equation might seem to present a rather surprising result, for once again the relative price is absent as a predictor. However, upon reflection, we should not in the end find this so surprising. For many businesses, the long-distance call has become an indispensable instrument of commerce. Even if long-distance rates were several times their present levels the phone would still, in many instances, be the least costly mode of communication, especially when the time element is taken into account. Since a substantial proportion of long-distance telephone use by business is for marketing purposes, a measure of relative price more relevant than the one we have used would be the long-distance rate relative to the cost of sending an agent into the field. The omission of such a variable from equation (16) probably accounts for the large (long-run) income elasticity obtained.

Total business revenue

$$(17) \qquad \underset{}{q_t} = \underset{(2.80)}{185.53} + \underset{(3.71)}{.5433}\, q_{t-1} + \underset{(2.88)}{.00652}\, x_t - \underset{(-3.45)}{1.5370}\, p_t$$

$$R^2 = .998 \qquad S_e = 4.87 \qquad DW = 1.67$$

elasticities (calculated at 1967 levels)

	income	relative price
SR	.27	-.39
LR	.93	-1.33

q = total business revenue of Bell Canada (in millions)/price index for telephone service for businesses [12/]

x = personal disposable income for Ontario and Quebec in millions of 1967 dollars

p = price index for business telephone service/implicit deflator for GNP (1967 = 100).

This equation presents a number of anomalies. Statistically, it is perhaps the best equation in this chapter, for all coefficients are at least twice their standard error, the R^2 is very high, and there is only a hint of autocorrelation in the residuals. The problem, however, is that the equation is seriously out of line with the equations for local service and long distance; the relative price is absent from both equations (15) and (16), but it shows up strongly in equation (17)! And, probably not independent of this, the (long-run) income elasticity for the combined revenues is less than for either of the components. While it is quite possible to explain this as a statistical phenomenon, an economic interpretation is another matter. For the moment, we must leave it as a statistical quirk.

12/ Calculated as .617 p_{ls} + .383 p_{ld}, where ls and ld refer to local service and long distance, respectively, and where the weights again are averages of the initial and final shares of the revenue categories concerned in total business revenue.

Total revenue of Bell Canada

The following equation was estimated to describe total Bell Canada revenues:

$$\text{(18)} \quad q_t = \underset{(.15)}{18.52} + \underset{(4.64)}{.7594}\, q_{t-1} + \underset{(1.62)}{.00492}\,(x_t + x_{t-1}) - \underset{(-.94)}{.3266}\,(p_t + p_{t-1})$$

$R^2 = .999$ $\quad S_e = 4.92$ $\quad DW = 2.46$

elasticities (calculated at 1967 values)

income	1.57
relative price	-.39

q = total revenue of Bell Canada (in millions)/implicit deflator for Bell total revenue (from Olley study)

x = personal disposable income for Ontario and Quebec in millions of 1967 dollars

p = implicit deflator for Bell total revenue/implicit deflator for GNP (1967 = 100).

We have presented the equation for the total revenue of Bell Canada last rather than first in order to appreciate better why it is both inaccurate and misleading to speak of a single all-encompassing demand for telephone services. The preceding subsections have demonstrated quite clearly that there are at least four unambiguously defined submarkets for telephone communications, and we would probably find even more if further disaggregation of the data were possible. The demand for telephone services for all customer and service categories combined thus reflects the interplay of each of the submarkets we have studied, and this must be kept in mind in interpreting the equation presented in (18), and more particularly in assessing the equation for total revenue estimated from DBS data [equation (3)].

Perhaps the most significant aspect of equation (18) is the weakness, both statistically and quantitatively, of the relative price. While this is in keeping with other equations for Bell Canada -- all, that is,except for equation (18) just discussed -- it is quite at variance with equation (3). Since Bell revenues are a substantial part of the total, one would expect, especially in view of the results of Section V.2 which suggest that the demand for telephone services in Canada is homogeneous with respect to region, that equations (3) and (18) would be in closer agreement. The income elasticities agree quite well, but the (long-run) price elasticity in equation (3), it will be recalled, is well in excess of two. Since, strictly speaking, the Bell implicit deflator is appropriate only to that part of total revenue which is Bell's, the problem probably lies in equation (3) rather than equation (18). This is because, as was noted at the time when we were discussing equation (3), incorrect deflation will lead to a downward bias in the estimate of the price elasticity. Since this is the case, we must put more confidence in the price elasticity estimated in equation (18) than in the one estimated in equation (3).

4. Evaluation of the results for telephone

At this point, it will be useful to draw together the major considerations of the preceding pages:

1. The demand for telephone services is characterized by strong habit formation. This is reflected in a short-run response in demand to a change in income or relative price that is small compared with the response in the long run.

2. The long-run elasticity of demand with respect to income is well in excess of one. This is true not only in the aggregate, but also for residences (both local service and long distance), and businesses (also both local service and long distance) taken separately.
3. Local service for both households and businesses and long distance service for businesses appear to be independent of relative price.
4. On the other hand, the demand for long-distance services on the part of households displays a substantial long-run price elasticity.
5. The demand for telephone services in Canada appears to be homogeneous across regions.
6. The statistical quality of the estimated equations varies from excellent to only fair. The fits of the equations are extraordinarily tight, even for time-series data, and there are no problems of autocorrelated residuals. The coefficients of income and price are often not as significant statistically as one would prefer, but much of the time this can be attributed to strong trends in the data which introduce an undesirable amount of intercorrelation into the explanatory variables.

V. Empirical Results II: Telegraph and Cable

Our analysis of the telegraph and cable subsector of the telecommunications industry employs the same Houthakker-Taylor approach as was used above, with revenue from the particular service under discussion taken to be the dependent variable in each equation. Because of the dominance of telephone services in total sector revenue, our investigation of demand for telegraph and cable has been less extensive than for telephone, and this emphasis (or lack of it) is reflected in the discussion which follows.

Unlike the telephone industry, where revenues are dominated by local- and long-distance voice message components, the telegraph industry derives its revenue from a more diffuse set of services, and as far as possible, our analysis has taken account of this diversity. Our sources of data have been three. Time series for several categories of service are identifiable from the DBS publication, Telegraph and Cable Statistics, and these have been augmented with data made available by CN-CP Telecommunications, which provide a breakdown of service categories different from that given in the DBS data. Finally, we requested and received from the Trans-Canada Telephone System data on certain services competing directly with the telegraph and cable carriers, and we have analyzed these both on their own and aggregated with CN-CP data.

The services of telegraph and cable companies appear to be largely directed at business users. In discussion, representatives of CN-CP estimated that revenue from telegrams constitutes only about 16% of their total revenue, and in turn that only about 16% of telegram

revenue derives from "social" rather than business use. Household or consumption use of services other than telegram is considered to be negligible.

Given the importance of business use in total revenue, the appropriate measure of income or activity level would seem to be gross national product (GNP) deflated by the implicit deflator for GNP to yield a measure of real income. However, because a substantial part of business use of telegraph and cable service may be in the nature of "overhead" activity or input into cyclically insensitive sectors, it is possible that a smoother income series, more akin to a measure of 'permanent' income, might be more appropriate. For this reason it makes sense to try a measure like personal disposable income, deflated by the GNP deflator, as an alternative index of income, and this we did. Since personal disposable income appeared to give marginally better results, it is the variable we employ in what follows.

With respect to price data, the situation is also somewhat complicated. Both CN and CP have stated that prices for services other than public-message cable and money orders have not changed. Therefore, as an index of the prices for equipment rental, broadcast, and Telex service relative to the prices of all other goods and services, we have used the reciprocal of the GNP deflator. This variable proved to be insignificant in our analysis and has not been included in the final equations reported here.

Prices for public-message services have changed, and for this category of service three possibilities suggest themselves. The first is to create an average price variable by taking the ratio of public-message service revenues to total number of telegrams (both series being reported

annually by DBS in Telegraph and Cable Statistics), thus obtaining a series on average price per telegram. Deficiencies arising out of the failure to take any account of possible changes in the distribution of calls over mileage bands, message lengths, or message class are obvious in this variable, and its relatively poor performance is therefore not surprising. In the end we elected not to use it. A second possibility is to draw from the tariff schedule the price of a specific message, while a third is to construct a weighted price index.

Representatives of CN-CP Telecommunications made available to us a set of public message tariffs by mileage band for the period from 1947 to the present, together with estimates of the overall price increase implied by each rate table change, obtained by weighting increases for each message category by the relative importance of that category in overall public-message service revenues. Chaining these estimates, we established a price index for public-message services, with 1947 taken as a base year and later values calculated by accumulating the company-supplied weighted percentage rate increases.[13/] At the same time we extracted the price of a 25-word telegram sent from Montreal to Toronto, to serve as the alternative price measure.[14/] All three series were then deflated so as to take a value of 1.00 in 1967, and relative price series were then obtained by dividing by the GNP deflator, so as to yield a measure of the price of public-message services relative to all other goods and services.

13/ Rate changes occurring in mid-year were averaged appropriately.

14/ The 25-word length was selected so as to avoid some of the difficulties associated with the change, early in 1967, from 10 words to 15 words as the length of the telegram to which the minimum charge applies. As with the previous series, appropriate averaging was undertaken where necessary.

With price and income variables thus available, regression equations were estimated for the revenue categories listed at the beginning of this chapter with results as described in the following section.

DBS Revenue Categories

Regression equations were estimated for total industry revenue as reported by DBS, and for various subtotals. The first of these subtotals was obtained by adding revenue from 'leased circuit' and 'other leased plant' to obtain a series we called 'total leasing revenue'. Subtracting this from total industry revenue left a residual which we called 'transmission revenue'. (This series, it should be noted, includes revenues from many different services, among them telephone, telex pulse, broadcast and public-message service revenues.) Finally, from this residual we isolated public-message service as a separate category.

For each equation in this section the data extend from 1950 to 1967, but the introduction of a lagged variable required us to estimate the equation for the period 1951 to 1967.[15/]

Since almost all telegraph revenue derives from business sources, the underlying demand decisions will presumably reflect the number of businesses or - more likely - the scale of business operations rather than individual incomes and requirements. Thus we expect the equations estimated in an aggregate, rather than per capita, form to be superior, and this expectation was confirmed by our computations. Therefore we present only the aggregate equations

---

[15/] 1968 data for COTC, which accounts for almost all of the difference between CN-CP revenues and total telegraph and cable sector revenues, are sufficiently odd that we have chosen not to extend the sample period to include the 1968 observation in the equations for DBS revenue categories, although we have done so with respect to the CN-CP categories, which are not affected by the COTC estimates.

For total revenue as recorded by DBS, the following equation was obtained using the stock-adjustment model under the restriction that A_3 equals A_2:

Total revenue:

$$(19) \quad q_t = -9.15 + .8821\, q_{t-1} + .000662\, x_t$$
$$\quad (-1.3) \quad (6.0) \quad (1.4)$$

$R^2 = .994 \quad S_e = 1.85 \quad DW = 1.22$

income elasticity (calculated at 1967 values).

short-run	.14
long-run	2.30

q = total industry revenue (in millions)

x = personal disposable income (in millions)/GNP deflator (1967 = 100).

This equation shows an income elasticity of .14 in the short run and 2.30 in the long run, confirming the relative insensitivity to cyclical fluctuations that we have come to expect of the demand for telecommunications service. Here, as below, the relative price variable based upon the reciprocal of the GNP deflator proved insignificant. A more appropriate price variable can be imagined, of course; one would like to see a weighted average which included the changing price of public-message service. But since more direct investigation of possible price effects can be undertaken in the context of the disaggregated equations, we need not pursue the issue here. Despite the high R^2, the statistical quality of this equation leaves something to be desired. The coefficient of income is less than twice its standard error, and for the first time in this chapter there is an indication of positive autocorrelation in the residuals (as evidenced by the Durbin-Watson coefficient of 1.22).

Separating what we call 'leasing revenue' from what we call 'transmission revenue' leads to the following two equations:

"Transmission revenue"

(20) $$q_t = -7.126 + .4802\, q_{t-1} + .000826\, x_t$$
$$\quad (-2.5) \qquad (2.1) \qquad (2.7)$$

$R^2 = .979$ $\quad S_e = 1.48$ $\quad DW = 1.33$

income elasticity (calculated at 1967 levels)

short run .44

long run 1.26

q = total industry revenue as reported by DBS, less revenue from DBS categories "leased circuit" and "other leased plant" (in millions)

x = personal disposable income (in millions)/GNP deflator (1967 = 100)

"Leasing revenue"

(21) $$q_t = -7.32 + .8420\, q_{t-1} + .000226\, (x_t + x_{t-1})$$
$$\quad (-1.2) \qquad (5.1) \qquad (1.4)$$

$R^2 = .985$ $\quad S_e = 1.81$ $\quad DW = 1.56$

income elasticity (calculated at 1967 levels): 2.28

q = revenue from DBS categories "leased circuit" plus "other leased plant" (in millions)

x = personal disposable income (in millions)/GNP deflator (1967=100)

As might be expected from the contractual nature of much of "leasing revenue", the inertia in this category is significantly higher than for transmission revenue, even though in the long run the income elasticity of leasing revenue (2.28) is greater. Both categories of revenue have grown faster than income in the period under study. With "transmission revenue" there is once again evidence of positive autocorrelation in the residuals.

Breaking revenues from leased facilities in turn into the two separate components "leased circuits" and "other leased plant", we arrive at the two equations:

"leased circuit"

$$(22) \quad q_t = \underset{(-1.1)}{-5.166} + \underset{(4.2)}{.7886}\, q_{t-1} + \underset{(1.4)}{.0001796}\, (x_t + x_{t-1})$$

$R^2 = .969 \qquad S_e = 1.78 \qquad DW = 1.45$

income elasticity (calculated at 1967 levels): 2.01

q = revenue from "leased circuit" (in millions)

x = personal disposable income (in millions)/GNP deflator (1967 = 100).

"Other leased plant"

$$(23) \quad q_t = \underset{(-2.0)}{-2.65} + \underset{(8.6)}{.9027}\, q_{t-1} + \underset{(2.1)}{.0000658}\, (x_t + x_{t-1})$$

$R^2 = .997 \qquad S_e = .26 \qquad DW = 1.62$

income elasticity (calculated at 1967 levels): 4.02

q = revenue from "other leased plant" (in millions)

x = personal disposable income (in millions)/GNP deflator (1967 = 100).

In both cases the most satisfactory form of equation comes with the flow-adjustment model (which also yielded the most satisfactory results in the equation for total leasing revenue). The income elasticity for equation (22) is 2.01, while that for equation (23) is 4.02. Since "other leased plant" refers primarily to the leasing of terminal equipment, the high income elasticity undoubtedly reflects the recent rapid growth of Telex, remote-access computation, and data transmission.

Finally, from "transmission revenue" the revenues from public-message service can be broken out, and the equation for this category contrasts sharply with those for the leasing services.

"Public-message service"

$$(24) \qquad q_t = \underset{(3.9)}{34.504} + \underset{(3.3)}{.4806}\, q_{t-1} - \underset{(-3.2)}{.000194}\,(x_t + x_{t-1}) - \underset{(-1.9)}{6.4729}(p_t + p_{t-1})$$

$R^2 = .966 \qquad S_e = 1.19 \qquad DW = 1.79$

elasticities (calculated at 1967 values):

income	-2.57
relative price	-2.02

q = revenue from public message service (in millions)/ price index constructed from CN-CP weighted average price increase estimates

x = personal disposable income (in millions)/GNP deflator (1967 = 100)

p = price index constructed from CN-CP weighted average price increase estimates/GNP deflator (1967 = 100).

For this category, there is a negative relation to income (an income elasticity of -2.57), and, for the first time, a significant dependence upon relative price. The price elasticity estimated from this equation is surprisingly strong, with a value of -2.02. It is particularly surprising that the public-message category should be the only one to reveal a strong price dependence. However, there are three points to be kept in mind in assessing this result. The first is that the public-message service revenue category may be the only one of the DBS categories to correspond at all closely to a specific telegraph and cable service. Secondly, equation (24) is the first of the telegraph equations for which we have had available a price deflator tailored to the service under study, and hence have been able

to deflate the dependent variable properly. (Although it is argued that the prices of other services have remained unchanged over our sample period, in fact these services are subject to very complex contracting arrangements and leasing terms, changes in which could be considered a change in the effective price of service, particularly relative to services offered by the telephone system.) Finally, the statistical bias alluded to earlier, resulting from use of the independent price variable to deflate the dependent variable, may act to exaggerate the observed price elasticity.

These equations thus give us relationships describing total industry revenue, its breakdown into (roughly) transmission revenue and leasing revenue, and the decomposition of the latter into "leased circuits" and "other leased plant". In all these equations substantial long-run income elasticities are noted, though the actual fraction of income devoted to any of these services is very small. All these equations showed a negative intercept term, indicating a growth of revenue faster than the growth of income, so that the share of income directed toward telegraph and cable services is increasing. The exception to all this discussion is public-message service, where revenues are declining while income rises. Our equation suggests a substantial price elasticity, a result which is at variance with what seems to be general opinion within the industry. Even so, however, the price coefficient is barely significant, and, allowing for some bias arising from the negative correlation of the independent variable with our constructed dependent variable, the hypothesis cannot be rejected that demand for this category of service is inelastic with respect to price.

With the use of data supplied by CN-CP, it is possible to study revenues on a breakdown corresponding more closely to actual service divisions than does the DBS breakdown. The following section describes the results of our analysis of these data.

CN-CP Categories

From the data supplied by CN-CP, we have chosen to analyze revenues from message cable service (public message plus cable plus money order), Telex[16/], program broadcast transmission, and private wire plus equipment rentals, together with total CN-CP telecommunications revenues.

The sample period is 1956-68, the longest period for which both CN and CP data are available. Taking into account the lagged dependent variable, the regressions apply to the period 1957-68, except for Telex revenue, which, since it was zero in 1957, only covers the period 1958-68.

For total CN-CP telecommunications revenue, the equation selected was from the state adjustment model estimated under the restriction that A_3 equal A_2.

Total CN-CP revenue

$$(25) \qquad q_t = -10.59 + .7414\, q_{t-1} + .000813\, x_t$$
$$\qquad\qquad (-1.8) \qquad (3.8) \qquad (1.8)$$

$R^2 = .993 \quad S_e = 1.37 \quad DW = 1.75$

income elasticities (calculated at 1968 values)

short run	.25
long run	1.68

16/ Though ideally we should analyze pulse revenue separately from equipment rental, the CP data available to us do not distinguish between these revenues.

q = total CN-CP telecommunications revenue (in millions)

x = personal disposable income (in millions)/GNP deflator (1967 = 100).

The income elasticities estimated from this equation are .25 in the short run, and 1.68 in the long run. Comparing these results with equation (19) estimated from DBS data for the industry as a whole (including COTC and other small companies), we see that the latter shows a somewhat slower response to a change in income, but a larger elasticity in the long run. One may speculate that this feature reflects the overseas message service component, but we have not pursued this.[17]

Turning to individual services, the first equation refers to private wire plus equipment rentals. For this category the simple static model, for the first time in this chapter, yields the best results, with the estimated equation being:

Private wire plus equipment rentals

(26) $$q_t = \underset{(-3.1)}{-11.21} + \underset{(9.8)}{.00982}\, x_t$$

$R^2 = .905 \quad S_e = 1.90 \quad DW = .41$

income elasticity (calculated at 1968 values): 1.42

q = revenues from private wire and equipment rentals (in millions)

x = disposable personal income (in millions)/GNP deflator (1967 = 100)

Relative to the other equations in this chapter, this equation has both a low R^2 and a serious problem with autocorrelation in the residuals,

---

[17] Examination of COTC data as set out in Public Accounts would be of interest in this regard.

as indicated by the low value of the D.W. statistic, but thus far we have not been able to improve upon it. The equation implies an income elasticity of 1.42, a lower value than the elasticity of 2.28 estimated from equation (21) using the DBS data for leased plant and circuits, to which this CN-CP series corresponds most closely.

For revenue from program broadcast transmission -- the trunking of broadcast material or transmission from station to radio or TV transmitter -- the estimated equation is of the flow-adjustment type:

Broadcast transmission revenues

(27) $$q_t = \underset{(-3.6)}{-2.49} + \underset{(1.6)}{.2053}q_{t-1} + \underset{(5.8)}{.0000579}(x_t + x_{t-1}) + \underset{(6.1)}{1.235}D_t$$

$R^2 = .8788 \quad S_e = .17 \quad DW = 1.29$

income elasticity (calculated at 1968 levels): 1.93

q = revenue from program broadcast transmission (in millions)

x = personal disposable income (in millions)/GNP deflator (1968=100)

D = dummy variable taking the value 1 from 1957 to 1962 and zero thereafter, introduced to reflect the CN-CP loss of a large transmission contract to TCTS in late 1962.

For this equation we have a relatively high income elasticity of 1.93. The presence of some autocorrelation is indicated, but otherwise the statistical quality of the equation is acceptable. (With the inclusion of the dummy variable not many degrees of freedom remain from the short sample period in any case.) No significant price dependence is indicated.

For Telex service, the most satisfactory equation we have estimated is of the old-fashioned static type, as follows:

Telex service

(28) $$q_t = -39.76 + .001411\, x_t$$
$$(19) \qquad (24)$$

$$R^2 = .984 \quad S_e = 1.03 \quad DW = .93$$

income elasticity calculated at 1968 levels: 2.54

q = revenue from Telex service (in millions)

x = personal disposable income (in millions) GNP deflator.

Again the income elasticity is high substantial autocorrelation problems are evident, and the price variable proves insignificant. Although alternative regression equations have displayed more substantial price elasticities, they ere even less acceptable statistically and less consistent with the aggregate equations.

The most striking equation for the CN-CP revenue catergories, as for the DBS categories, relates to public message service. The equation is:

Message cable revenue

$$q_t = 6.47 + .7410\, q_{t-1} - .0000289\, (x_t + x_{t-1})$$
$$(.6) \qquad (2.0) \qquad (.5)$$

$$R^2 = .92 \quad S_e = .52 \quad DW = 1.77$$

income elasticity calculated at 1968 levels: -.60

q = message cable revenue (in millions)

x = personal disposable income (in millions 1961 dollars)

Although this equation displays a reasonably good fit to the revenue category, neither income nor constant terms are significant. The equation is therefore that of a simple process of decay. The income elasticity of -.60 can be compared with that of -2.57 estimated from the equation for DBS public message service category. The striking feature of the comparison, however, is

that, unlike with the DBS data, the CN-CP data do not indicate any dependence on relative price. It should be emphasized, though, that among the difficulties attending this analysis is the fact that the services are new, the series are short, and the magnitudes involved are relatively small.[18] Moreover, in many of the services there exists substantial competition with the telephone companies, so that revenues may reflect changes in conditions of competing services rather than changes in demand.

For this reason we requested, from TCTS, data on a number of similar services offered by the telephone companies. In some cases it proved impossible to assemble the required series in the time at our disposal, while in other cases the classifications of revenues were not fully compatible between carriers. Nevertheless, TCTS were able to supply data on revenues from TWX rentals from 1965 on, private wire, and program broadcast transmission (the last being an incomplete and possibly inconsistant tallying of individual company revenues from this service class). With these data we ran two regressions, one for broadcast revenues, and the other for rental revenues (aggregating the private wire and TWX series for the purpose); the estimated equations are given below:

<u>Telephone company "broadcast" revenues</u>

(29) $$q_t = \underset{(-2.6)}{-6.99} + \underset{(1.7)}{.3752}\, q_{t-1} + \underset{(2.9)}{.000168}\,(x_t + x_{t-1})$$

$R^2 = .983 \quad S_e = .42 \quad DW = 2.13$

income elasticity (calculated at 1968 levels): 1.87

---

[18] Those difficulties are in addition to that mentioned earlier, that the services are covered by contracts whose terms or conditions may change in ways that cannot be captured in single price indices.

q = telephone company "broadcast" revenues (in millions)

x = personal disposable income (in millions)/GNP deflator (1967 = 100).

Telephone company "rental" revenues

(30) $$q_t = -26.59 + .00121\, x_t$$
$$\quad\;\; (-7.2) \qquad\quad (12.)$$

$R^2 = .931 \qquad S_e = 1.97 \qquad DW = .570$

income elasticity (calculated at 1968 levels): 2.02

q = telephone company "rental" revenues (in millions)

x = personal disposable income (in millions)/GNP deflator (1967 = 100).

The flow-adjustment equation for broadcast revenues is of acceptable statistical quality, with significant coefficients, the usual high R^2, and a DW statistic close to 2. The measured income elasticity from this equation is 1.87, as compared to the value of 1.93 recorded for the same service for the telegraph companies.

The static model for rental service, on the other hand, is less appealing statistically, but is comparable in this regard to the equation estimated for the same category of telegraph revenue. The relevant income elasticity is 2.02 for the TCTS data, as compared with a value of 1.42 reported earlier for the telegraph service.

Aggregated data for unregulated services

By aggregating the data series across comparable services offered by the separate carriers, we are able to estimate equations describing total sector demands for Telex-TWX, rental, and broadcast services without distinguishing the carrier offering the service. The three equations are:

TWX - Telex revenue

(31) $$q_t = -47.22 + .00165\, x_t$$
$$\qquad\quad (-16.) \qquad (21.)$$

$R^2 = .979 \quad S_e = 1.38 \quad DW = .712$

income elasticity calculated at 1968 values: 2.61

q_t = CN-CP Telex + TCTS TWX revenue (in millions)

x_t = personal disposable income (in millions) GNP deflator (1967 = 100)

This equation suffers from the same serial correlation problems that appear in all the equations based on the static model. Nonetheless, the ratios are sufficiently high to remain significant even after the standard errors are adjusted for serial correlation. The income elasticity in the equation of 2.61 is very close to the value of 2.54 found in equation 28.

In contrast, the equation for total broadcast revenue is more consistent with the equations estimated for its components. Combining the data of course removes the need for introduction of any dummy variable to take account of shifts of service between the carriers. The equation is:

Broadcast revenue

(32) $$q_t = -3.64 + .5027\, q_{t-1} + .000147\,(x_t + x_{t-1})$$
$$(-.9) \quad (1.4) \qquad (1.6)$$

$R^2 = .961 \quad S_e = .67 \qquad DW = 1.66$

income elasticity (calculated at 1968 values): 1.62

q = total revenue from broadcast program transmission for TCTS and CN-CP (in millions)

x = personal disposable income (in millions)/GNP deflator

The income elasticity estimated from this equation is 1.62, as compared with 1.87 for the telephone component and 1.93 for the telegraph component when these are analyzed separately.

Finally the equation yielding the best results for rental revenues, based on a conventional static model, is

Rental revenue

(33) $$q_t = -37.80 + .00219\, x_t$$
$$(-5.4) \qquad (11.)$$

$R^2 = .924 \quad S_e = 3.75 \qquad DW = .39$

income elasticity (calculated at 1968 levels): 1.70

q = total revenue from rental for TCTS and CN-CP (in millions)

x = personal disposable income (in millions)/GNP deflator

The income elasticity of 1.70 associated with this equation compares with 1.42 and 2.02 for the telegraph and telephone compnents, respectively.

Conclusions for telegraph and cable

It is clear from the foregoing that the results for telegraph and cable are considerably less satisfactory than those for telephone. The equations are generally of lower quality statistically -- coefficients are less significant, R^2's are not as high, and positive autocorrelation in the residuals has made a belated appearance -- and there are clearly more anomalies than with telephone. The relative price is absent from the majority of categories analyzed, and the income elasticities in several might seem a bit high. The statistical problems with the CN-CP and TCTS categories no doubt reflect in part the fewness of observations with which we had to work, but there is probably something more fundamental at issue, not only with the CN-CP categories, but with the DBS categories as well.

We have in this chapter totally ignored supply. Not only is this traditional in empirical demand analysis, but it would seem to be especially appropriate with regard to the demand for telephone services, for the conventional view (within the industry, certainly) is that telephone companies forecast demand for a number of years ahead and then make certain that there is adequate capacity to service this demand when it materializes. Thus, for telephone, capacity should never be a constraint on demand.[19/] With telegraph and cable, however, hindsight suggests that supply cannot be safely ignored. It is not that transmission capacity has ever set more than a theoretical

---

19/ A notable exception to this, however, though relevant to Canada only in terms of the lesson to be drawn, was in New York City in the 1960's when the New York Telephone Company failed to anticipate the rapid increase in data transmission.

upper limit to the volume of service that could be provided, but rather that new capacity put in place, especially the completion of the CN-CP Trans-Canada microwave facility in 1963, made possible the provision of a variety of services, particularly those relating to data transmission, that previously the telegraph companies were ill-equipped to provide. Thus, the problem in essence is one of new services. A similar problem exists in the telephone industry, but there the problem, at least during the period of analysis, is of less importance and can be ignored. With telegraph, however, this is not the case, for the putting-into-place of data transmission capacity quite clearly gave the telegraph industry a shot in the arm. The upshot of this is that those revenue categories involving data-transmission revenues as a component should be analyzed as two subperiods, with the break being at 1963. This task, however, must remain for the future, for the short time series clearly preclude it being undertaken now.

V. Empirical Results III: Aggregate Telecommunications Sector

The previous two sections have examined revenues of the telephone subsector separately from those of the telegraph and cable subsectors. But for the user -- whether household or firm -- the services of these subsectors are to some extent simply alternative means to an end, and, while the characteristics of one subsector or the other may be better suited to a particular purpose, it is probably appropriate in many cases to think simply of an overall demand for telecommunications service. In this section we adopt such a point of view, estimating an equation for total sector revenues, and then separating out total household demand for telecommunication services as estimated from data from the personal consumption expenditure tables of the National Income Accounts.

For the aggregate equation we have:

Total telephone and telegraph and cable revenue

(34) $$q_t = -347.44 + .0259\, x_t - 1.3325\, p_t$$

$$\quad (-.70) \qquad (10.24) \qquad (-.41)$$

$R^2 = .991 \qquad S_e = 28.57 \qquad DW = 1.32$

elasticities (calculated at 1967 levels)

income	1.34
relative price	-.11

q = total revenue of telephone, telegraph, and cable companies (in millions)[20]

x = GNP in millions of 1967 dollars

p = implicit deflator for total revenue of Bell Canada/implicit deflator for GNP (1967 = 100).

---

[20] Telephone revenues are deflated with the implicit deflator for total revenue of Bell Canada; telegraph and cable revenues are undeflated.

As can be seen, this equation is based on a conventional static model (a fact which is a little disappointing in itself) and shows no significant price dependence. Given the earlier results of this chapter showing the substantial variation in behaviour among the various sectoral or service divisions, and particularly given the inadequacies of the price measures employed here, however, a failure to obtain a successful equation for the aggregate containing all these diverse services is hardly surprising. Nevertheless we include the equation here as a convenient summary of the fraction of GNP represented by sales of telephone and telegraph services, both intermediate sales to business, and final sales to households and government.

To deal with final sales (of the sector as a whole) to households, one may turn to an analysis based on expenditures by the user, rather than on revenues of suppliers. For personal consumption expenditure, this analysis has been carried out in detail by Professor Bakony in a companion study. For summary purposes we present here only a single equation of Houthakker-Taylor type describing consumer expenditure on communication services, estimated by Dr. T.T. Schweitzer of the Economic Council of Canada as part of a detailed study of consumption patterns in Canada. Dr. Schweitzer has kindly made available to us the equation which follows:

(35)
$$q_t = \underset{(15.1)}{.938}\, q_{t-1} + \underset{(5.1)}{.00740}\,\Delta x_t + \underset{(1.67)}{.00169}\, x_{t-1} - \underset{(-3.9)}{.02685}\,\Delta p_t - \underset{(-2.8)}{.00612}\, p_{t-1}$$

$R^2 = .998$ $\qquad$ $DW = 1.77$

elasticities (calculated at 1966 values)

	short-run	long-run
income	.44	1.78
price	- .09	- .36

where q = personal consumption expenditure on telephone, cables and telegraphs, and postage per-capita/implicit deflator for communications expenditures

x = total personal consumption expenditure per-capita deflator for personal consumption expenditure

p = implicit deflator for personal consumption expenditure on communications service/implicit deflator for total PCE.

This equation, it should be noted, includes postal services, and so is not strictly comparable to our earlier equations. Nevertheless, it displays the same low short-run, and high long-run, income elasticities as we have found to characterize almost all telecommunications categories, and the same apparent insensitivity to price movements.

With this equation we conclude our analysis of expenditures on telephone and telegraph services. Further analysis of the determinants of personal consumption expenditure on these categories we leave to the study undertaken by Professor Bakony and more detailed market projections for particular industrial services we must leave to the studies prepared by the common carriers for the Telecommission.

VI. Concluding Discussion

The demand for telecommunications services has several facets. Our results have shown quite conclusively that demand is not homogeneous across users. Business demand differs from that of households, and long-distance differs from that of local service.

In general, one expects the demand for telephones themselves to be determined primarily by demographic factors (particularly the growth in the number of people just entering the labour force and the rate of family formation) and per-capita income. Our equation for the total number of telephones (see footnote 8) confirms that this is the case, for the growth in telephones per 100 population is strongly related to the growth of per-capita income. And, through extension phones and other special features, this influence can be expected to continue even as the number of telephones per 100 households approaches 100. With careful demographic analysis, these relations could be elaborated, but we have not undertaken such work; this has been left to the studies of Bakony, and market projections of the common carriers. It would be possible to undertake a straightforward projection of DBS time series on numbers of messages handled, but again we have chosen not to do so. While numbers of messages may be an important -- indeed even dominant -- determinant of costs, it is not a satisfactory measure of demand. We have preferred instead to employ revenue measures, suitably deflated (where possible), as the dependent variable in our analyses.

The main results from our equations are:

1. The demand for telecommunication services in general displays a great deal of short-run inertia. This reflects the well-known fact that telecommunications is not a cyclical industry.

2. The demand for telephone services, whether business or household, local or long distance, is elastic with respect to income in the long run.
3. The demand for telegraph and cable services, except for public-message, is also elastic with respect to income.
4. The demand for telephone local service and the demand for long-distance service on the part of businesses is insensitive to changes in relative price. The demand for long-distance service by households, however, is elastic with respect to relative price.
5. The demand for telegraph and cable services shows no apparent sensitivity to relative price.
6. The demand for telephone services appears to be homogeneous across regions of the country.

With respect to the residence demand for communications services there are several issues we have not pursued. The rapid growth of metropolitan areas, and particularly their suburbs, will continue to alter the structure of local service, setting up pressures for further Extended Area Service arrangements. Increasing interest in more extensions and optional features will presumably continue. One such feature, which at present might be considered a frill, but evidently is introduced with an eye to later data transmission needs of households, is Touch-Tone dialing. What these developments, or the prospect of Daddy packing home his portable teletype with his brief case (as has already been done occasionally), will mean for residence

demand in the future, we cannot easily evaluate. To some extent the problem is one of detailed market analysis more appropriate to -- and better handled by -- the common carriers than ourselves. We can only take comfort, as we mentioned earlier, in the realization that these are developments which will evolve gradually, without becoming significant until the end of this decade, and without any great break in consumption habits.

Our discussion has also ignored some considerations with regard to business use. Time series observations for data transmission are too few to support regression analysis, and input-output data are too old to reflect this service at all. What is required is a complete input-output analysis based on a recent, disaggregated table, developing estimates of activity levels by sector and then, from outside information on the data transmission requirements of particular sectors, extrapolating the resulting demands upon the telecommunications sector. We cannot hope at this stage to develop a sufficiently detailed market analysis to generate estimates of this usage.

Perhaps it is worth offering a few general observations even here, however, since some of the discussion seems in danger of losing perspective. Data transmission -- and computing generally -- are still inputs into production processes, and still perform tasks similar to those already performed by one means or another. More planning, more efficient record-keeping, more elaborate analysis of data are all possible much more quickly and efficiently than before. But the purposes are the same and the considerations of usefulness and cost-effectiveness are not altered. Problems of privacy and file security and

liability for quality standards are aggravated with the introduction of the phenomenal capacity of modern equipment to absorb and massage data, but the problems are those of personal rights or property rights which have been with us since man first inscribed letters in a tablet.

Specifically we would discount predictions often made that government or educational demand for telecommunications will increase so explosively as to overwhelm the communications system. We do not believe that government operations within the decade will be able to absorb the data processing facilities and techniques necessary to create such demand, nor do we believe that time-shared computers or other computer-aided instruction will, on examination, prove an economic substitute for many educational functions. The development of small and low-priced, but quite powerful, computers should tend to offset trends to vast centralized data banks with extensive data transmission networks to scattered users.

Thus we end with a picture of a telecommunications sector dominated by telephone business, and a telephone sector in turn dominated by revenue from conventional telephone service to business, household and government. Traditional services will remain the primary revenue source, but the fastest growth will be associated with those services in which telephone and telegraph compete. The challenge to public policy in promoting orderly development of these services, without restricting the lively innovation and improvement that might result from this competition, is obvious.

APPENDIX TO CHAPTER III

Estimation of Demand Functions - Theoretical Background

The traditional approach in demand analysis is to estimate the demand function:

$$q_t = f(x_t, p_t\ z_{1t}, \ldots , z_{nt}, u_t), \tag{1}$$

where q_t is the quantity of the commodity purchased at time t, f is a mathematical function whose form will be specified later, x_t is the level of income, p_t is the price of the commodity, $z_{1t}, \ldots, z_{nt}$ are any other variables, such as lagged values of income and price or the prices of other commodities, and u_t is a random error term representing factors not otherwise taken into account or possibly errors of measurement in q. Once the form of f is specified, the parameters of the function are estimated by standard econometric techniques from either time series or cross section observations on the variables. Ordinarily, time series data are based on market statistics, while cross section data refer to individual spending units. Given the nature of our assignment which, among other things, required the estimation of price elasticities and the projection of the demand for telecommunications services to 1980, it was clear from the outset that we would have to rely on time series data, and this we have done exclusively.

Until recent years, the standard procedure in the estimation of the demand function in (1) has been to assume f to be linear in x and p (or possibly their logarithms), viz.:

$$q_t = \alpha_0 + \alpha_1 x_t + \alpha_2 p_t + u_t \tag{2}$$

Once this is done, the task is to estimate, using time series observations on q_t, x_t and p_t, the coefficients α_0, α_1, and α_2. This is usually done by the method of least squares. However, research of the last twelve to fifteen years has shown that the static specification represented by equation (2) is seriously deficient in explaining the demand for many commodities, for it fails to take into account the fact that consumers do not adjust their expenditure immediately when there is a change in income or price. This means that current expenditure is determined not only by current income and price, but also by the values taken by these quantities in the past, though it is naturally to be expected that the current values will receive the most weight.

There are a number of directions in which the demand function in (1) can be extended so as to capture this phenomenon, but the way that we have chosen is through the dynamic model of demand developed by Houthakker and Taylor (1970) in their extensive analysis of consumer demand in the United States over the period 1929 through 1975. This model takes as its point of departure the generally accepted notion, expressed in the preceding paragraph, that current decisions are influenced by past behaviour. To make this idea operational, the model postulates a particular type of relationship between the past and the present. The effect of past behaviour is assumed to be represented entirely by the current values of certain "state variables", of which inventories are a concrete (but not the only) example. These state variables are in turn changed by current decisions, and the net result is that of a "distributed lag": current behaviour depends on all past values of the explanatory variables, though more on recent values than on very remote ones.

The simple examples of Houthakker and Taylor will illustrate the principles involved. Let q(t) be an individual's demand for clothing during

a very short interval of time around t, let s(t) be his income during that interval, and let s(t) be his inventory of clothing at time t. All other variables will be ignored for the time being. The basic assumption is then that

$$q(t) = \alpha + \beta s(t) + \alpha x(t), \qquad (3)$$

which says that the individual's current demand for clothing depends not only on his current income, but also on his stock of clothing. We may expect that, for a person with given tastes and given income, the more clothes he has to begin with, the fewer he will buy currently, which means that, for a durable good like clothing, we should expect β to be negative. However, Houthakker and Taylor go on to show that, if a more general interpretation of s(t) is allowed, equation (3) may hold for other types of commodities as well. Indeed, not only can the model in equation (3) represent the stock-adjustment behaviour just described, but also habit formation or inertia, which Houthakker and Taylor find to be an even more widespread phenomenon.

Consider a commodity such as tobacco of which consumers do not normally hold physical inventories of any significance. By all accounts, tobacco consumption is habit-forming, which means that it does not adjust immediately to changes in income (or in prices either, for that matter) and that current consumption is positively influenced by consumption in the more or less recent past. In this case we can say metaphorically that the consumer has built up a psychological stock of smoking habits. His current consumption will be affected by that stock just as it is for clothing, but β will now be positive; the more he has smoked in the recent past, the more he will smoke currently (again on the assumption that tastes and income are given).

There is, of course, an obvious problem of measuring the stock variable when the commodity involved is characterized by habit formation, but Houthakker and Taylor stress that measurement is just as much a problem when s(t) refers to a physical inventory. In the case of clothing, s(t) cannot be represented simply by the number of suits, shirts, and the like, for some of these may be worn out and due for replacement; moreover, their heterogeneity also makes direct measurement hard. Clearly, some depreciated measure of inventories is needed, but the needed depreciation rates are usually not known a priori and would have to be either estimated from the data or guessed. Hence, even for durables, where the state variable has a concrete interpretation, it is desirable that it be eliminated.

This is done by making use of the relationship connecting the rate of change of the stock with respect to time, $\dot{s}(t)$, to q(t) and depreciation on the existing stock:

$$\dot{s}(t) = q(t) - \delta s(t) \ , \qquad (4)$$

where δ is a constant depreciation rate. This assumption of proportionality corresponds to the "declining balance" method of depreciation, which has been found to be realistic in many practical situations. For a good subject to habit formation, δ measures the rate at which the habit wears off. Taken in conjunction with equation (2), equation (4) allows the elimination of the unobservable variable s(t). We shall skip over the details of how this is done and also of how the model, which as formulated above is in continuous time, is approximated by one involving time in discrete intervals, and go instead to the estimating form of the model which involves only observable quantities:

$$q_t = A_0 + A_1 q_{t-1} + A_2 \Delta x_t + A_3 x_{t-1} \tag{5}$$

where $\Delta x_t = x_t - x_{t-1}$. Once estimates of the coefficients $A_0, \ldots, A_3$ are obtained, estimates of the "structural"parameters α, β, γ, and δ can be obtained from the equations:

$$\alpha = \frac{2A_0(A_2 - 1/2A_3)}{A_3(A_1 + 1)} \tag{6}$$

$$\beta = \frac{2(A_1 - 1)}{A_1 + 1} + \frac{A_3}{A_2 - 1/2A_3} \tag{7}$$

$$\gamma = \frac{2(A_2 - 1/2A_3)}{A_1 + 1} \tag{8}$$

$$\delta = \frac{A_3}{A_2 - 1/2A_3} \tag{9}$$

When the price of the commodity and the random error term are introduced into the model, the basic equation becomes

$$q(t) = \alpha + \beta s(t) + \gamma x(t) + \lambda p(t) + u(t) \quad . \tag{10}$$

The depreciation relationship remains valid as it stands in (4). The estimating equation corresponding to (10) and (4) now becomes

$$q_t = A_0 + A_1 q_{t-1} + A_2 \Delta x_t + A_3 x_{t-1} + A_4 \Delta p_t + A_5 p_{t-1} + v_t \ , \tag{11}$$

where v_t is a moving average function of $u(t)$. The relations connecting α, β, γ, and δ to $A_0, \ldots, A_3$ remain the same as before, and an estimate of λ is obtained from the equation:

$$\lambda = \frac{2(A_4 - 1/2A_5)}{A_1 + 1} \quad . \tag{12}$$

Short-term vs. long-term effects

One of the key features of the Houthakker-Taylor model is that it enables short-term effects to be distinguished from those that occur in the long-run. The short-run effect on consumption of a change in income is given by γ, the coefficient of income in equation (10). "Short-run" in this context is taken to mean the instantaneous change in consumption which occurs before the stock variable has had a chance to adjust. The long-run is then defined by the condition that stocks are fully adjusted to the new level of income. This requires that $\dot{s}(t)$ in equation (4) be equal to zero, which means that in long-run equilibrium:

$$\hat{q} = \delta\hat{s} \tag{13}$$

where $\hat{q}$ and $\hat{s}$ denote the long-term levels of q and s. Ignoring the error term, we also have from (10) that

$$\hat{q} = \alpha + \beta\hat{s} + \gamma\hat{x} + \lambda\hat{p}, \tag{14}$$

which upon substituting $\hat{q}/\delta$ for $\hat{s}$ from equation (13) becomes (after some manipulation):

$$\hat{q} = \frac{\alpha}{\delta-\beta} + \frac{\gamma\delta}{\delta-\beta}\hat{x} + \frac{\lambda\delta}{\delta-\beta}\hat{p} \quad . \tag{15}$$

From this equation we see that the long-term effect on consumption of a change in income is given by $\gamma\delta/(\delta-\beta)$, which differs from the short-term effect γ by the factor $\delta/(\delta-\beta)$. For $\beta < 0$, this factor will be less than one, which means that the long-run effect on consumption of a change in income will be less than the short-run effect. On the other hand, for β positive (but less than δ), the opposite will be true.

These two results point up the very important difference in dynamic behaviour between goods subject to stock adjustment ($\beta < 0$), and goods subject to habit formation ($\beta > 0$). The former react sharply in the short-run

to changes in income, while the latter may react hardly at all. With goods subject to habit formation, time is needed to overcome the inertia inherited from the past. In general, we shall find that this is the type of behaviour which describes the demand for telecommunications services.

Derivation of the short- and long-term effects on consumption of a change in price is parallel to that for income. From equation (10), the short-term effect is given by λ, while from equation (15) the long-term effect is seen to be equal to $\lambda\delta/(\delta-\beta)$. Once again, we see that the one differs from the other by the factor $\delta/(\delta-\beta)$. Consequently, as with a change in income, a change in price leads to a change in consumption that is greater in the long run than in the short run for goods subject to habit formation ($\beta > 0$), and the reverse for goods subject to stock adjustment ($\beta < 0$).

An alternative dynamic model

In a few cases, we have employed the alternative dynamic model that Houthakker and Taylor developed and used in their study. Unlike the model just described, which can be interpreted as an attempt on the part of the consumer to bring his stocks into line with income and price, the alternative model sees him doing this with regard to the flow. In its continuous-time form, the model consists of

$$\dot{q} = \theta(\hat{q} - q) \tag{16}$$

$$\hat{q} = \xi + \mu x + \pi p \ , \tag{17}$$

where $\dot{q}$ is the rate of change of consumption with respect to time and $\hat{q}$ is the desired level of consumption. The estimating form of the model is given by the equation:

$$q_t = A_0^* + A_1^* q_{t-1} + A_2^*(x_t + x_{t-1}) + A_3^*(p_t + p_{t-1}) + v_t \qquad (18$$

where once again v_t is a random error term. The parameters in (16) and (17) are connected to the A*'s in (18) according to the equations:

$$\theta = \frac{2(1-A_1^*)}{1 + A_1^*} \qquad (19$$

$$\xi = \frac{A_0^*}{1 - A_1^*} \qquad (20$$

$$\mu = \frac{2A_2^*}{1 - A_1^*}$$

In terms of equation (11), this model corresponds to $A_2 = 2A_3$, so that δ is indeterminate according to equation (9).

In keeping with Houthakker and Taylor, we refer to this model as the flow-adjustment model, in contrast to the first model which we refer to as the state-adjustment model.

REFERENCES

Houthakker, H.A. and Taylor, L.D. (1970), Consumer Demand in the United States, second and enlarged edition, Harvard University Press.

Olley, R.E. (1970), "Productivity Gains in a Public Utility - Bell Canada 1952 to 1967", paper presented at the Annual Meeting of the Canadian Economics Association, Winnipeg, 1970.

IV. PRODUCTION

1. Introduction

This chapter provides estimates of the contribution of each of the factors of production toward the output of the telecommunications industry.[1] In order to estimate the impact of the telecommunications sector on markets for inputs such as labour, equipment, and raw materials, it is necessary to know how such inputs are combined to create output, and how these input combinations may alter as a result of changes in factor prices, or shifts in technology.

As discussed in Chapter II, we have elected to use revenue as the output variable in our analysis. This procedure has drawbacks in demand analysis, but for analysis of production relationships, revenue is even less satisfactory as a measure of output, for it fails to capture many characteristics relevant in determining costs of production.[2] Nevertheless, since we lack any natural scalar unit of output, we fall back on the yardstick commonly used to aggregate different commodities, and employ revenue in constant dollars as our measure of output.

The enterprise which generates this output might be subdivided into three major activities, as illustrated in Figure IV-1. These are: local collecting and distributing (consumer loops), switching, and trunking. A different role and different technology are involved in each of these.

---

[1] For purposes of this chapter, the industry is defined so as to exclude radio and TV broadcasting, the post office, and communications equipment. It includes, in other words, SIC categories 544 (telephone) and 545 (telegraph and cable).

[2] One might expect that numbers of messages would be more appropriate, since most factor inputs into production of telecommunications services would seem to be required for setting up a circuit, rather than maintaining the connection. Operator handling or switching activity certainly has this feature. Moreover, input requirements ought to be largely independent of the timing of a call (apart from loading at busy-hour peaks), even though this has substantial influence on revenues. Nevertheless, our trials with messages as an output variable have been uniformly less successful than our analyses employing revenues, and we report only the latter here.

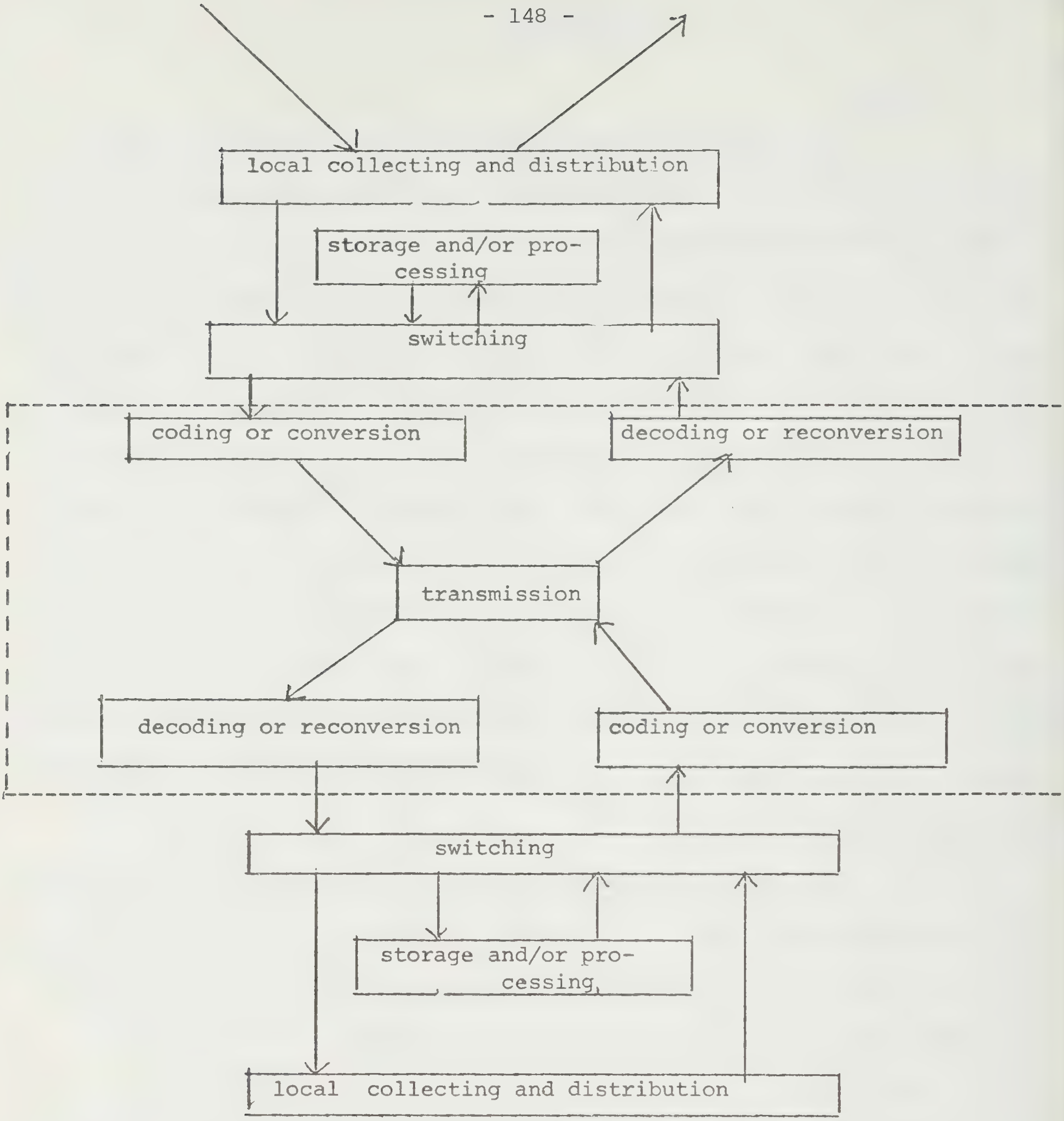


Figure IV-1

Schematic Display of Activities in Telecommunications Service

Collecting involves the terminal equipment -- telephones and teletypes or other peripheral equipment -- necessary to relay messages to, or collect messages from, individual callers, and local wire loops connecting the individual to a local switching centre. There switching equipment routes local calls to the appropriate local exchange, and toll calls to a nearby toll centre, at which point the call is routed to an appropriate trunk line. Trunking then is the process by which switched messages are transmitted to a geographically distant toll centre by means of wire line, coaxial cable, or microwave facilities.

Not all of the companies in the sector provide these three activities to the same degree. While the eight members of the Trans-Canada Telephone System maintain large trunking systems, most other telephone companies provide only local loops and local switching stations. It would clearly be uneconomic for each company (including those whose subscribers are concentrated in one small geographic area) to provide the trunks whereby its subscribers could connect with any person in Canada; on the contrary, it is efficient for geographically limited companies to rent trunking services as they are needed from the large telephone systems.

The telegraph and cable companies also provide a variety of services, but the majority of these may be interpreted as falling in the categories of switching and trunking.[3] We had hoped, in fact, to exploit this apparent specialization of function to learn something of the

---

[3] Canadian National provides telephone service in a large section of Newfoundland, employing its own local loops for the purpose. But outside this one province, the telegraph companies rely largely for local service on loops leased from the telephone companies.

productive characteristics of the trunking activity itself -- clearly this is information one would seek in studying whether separation of roles along the lines of these subactivities could result in viable firms -- but the data we have available proved inadequate to the task. Nevertheless the question obviously should be pursued in any fuller study of production conditions in the telecommunications sector.

Because of the joint use of common plant by most telecommunications services, estimates of the contribution of factor inputs to each activity separately are impossible to obtain from aggregate data. Long-distance voice messages, for example, involve the facilities of all three activities. It is impossible to separate equipment by type of output (at least within present classifications); the same problem exists, moreover, with respect to labour inputs. For a single company, therefore, the type of function one can estimate with the data presently available must involve aggregate revenue (or messages) as the dependent variable, with total capital and aggregate labour inputs for the firm as the primary explanatory variables.

Despite the fact that traditional work in industrial organization considers the plant as the basic unit in production, our specification must focus on the productive characteristics of the firm. The reason is simply that, although it is in the plant that technological economies in combining and enlarging related activities are usually assumed to arise, the distinction between firm and plant is blurred in the telecommunications industry. The geographic isolation which helps to define "the plant" for manufacturing industries does not aid us in this sector, for each activity is, by its very nature, geographically dispersed. As a result, statistical estimates of

productive characteristics can only be attempted for firms.

One immediate consequence of this limitation is that we are unable to analyze possible economies of scale within the separate activities, even though such economies might arise in any of the three major activities -- collecting, switching, and trunking -- or at the level of the firm.

The local network of telecommunications lines is similar in concept to other local networks such as gas and electricity distribution, or urban transit systems, the usual activities suggested by economists as examples of natural monopoly -- that is, as cases where long-run unit costs are lower if only one plant is permitted to serve the area. This definition of a natural monopoly does not imply that there must be economies of scale at all levels of output. Indeed, in principle a plant can be in the area of decreasing returns yet still be a natural monopoly, and at least one actual example of such a situation has been studied.[4] Therefore, we must be careful in distinguishing between economies of scale (resulting from proportionate increases in all factors, including capital) and lower costs due to increased utilization of fixed plant, with a spreading of the overhead over larger outputs. (The latter case clearly involves a movement along an existing plant curve.)

In fact, the usual reason for possible economies in large scale operations in the local drop-off activity is precisely the large fixed investment required in land rights-of-way, poles, and wires, an investment

---

[4] D.A. Bowers and W.F. Lovejoy, "Disequilibrium and Increasing Costs: A Study of Local Telephone Service", Land Economics, 41, 1965. Even though unit costs are increasing for the existing plant, these average costs may be lower than if two or more plants divided the output. Bowers and Lovejoy found apparent diseconomies of scale in local exchanges with more than 59,000 subscriber lines.

which evidently would render uneconomic any construction of duplicate facilities by additional firms[5], and which therefore provides a barrier to entry quite independent of any charter provisions, but an investment which does not necessarily generate economies of scale at every output.

Economies of scale in switching activities would appear to originate, if at all, in the greater flexibility of network management or traffic routing, and the more efficient utilization of backup facilities, possible in a large system. Certainly replication of existing switching equipment or toll certres should not in itself yield any economies of scale.

On the trunking activity, similarities can be noted to other transport systems such as railroads and pipelines. Here also, improved utilization of overhead facilities is more likely to be the source of decreasing unit costs than are any economies of scale to be enjoyed within the trunking activity. Since construction costs, rights-of-way and antenna systems are approximately 40-50% of the total costs of a microwave system, and since an increase in the number of working channels does not require a corresponding increase in the number of standby channels, the costs of increasing the existing microwave capacity are far less for additions to the existing networks than for

---

[5] The example sometimes cited as qualifying this proposition -- the recent growth of possible competition in the form of cable TV networks which could conceivably offer two-way communication -- of course does not invalidate the suggestion. These firms utilize existing telephone rights of way and poles, and likely would be unable to compete with the telephone companies if the latter elected -- and were permitted -- to refuse such use in order to enter cable TV activity on their own.

building complete new systems. Thus, the conclusion seems inescapable that increased utilization of the existing microwave systems should result in lower unit costs for the trunking activity. The replication of microwave systems, however, seems likely to move in the opposite direction.[6]

At the firm level, the common scale economies are in organizational activities, the purchases of inputs of supplies, financial and capital market dealings, and in advertising and promotion.

Thus there are several distinct considerations which might give rise to possible economies of scale within the different activities of the communications sector. Our analyses based upon data for the firm rather than its separate activities cannot isolate any of these causes individually, nor separate them from simply increased utilization of overhead plant.

A similar difficulty arises in attempting to compare results for separate firms or subsectors of the industry. Enterprises in the industry offer different mixes of services and face different cost curves within their separate activites; this heterogeneity of services provided means that neither the production functions nor the input requirements functions for different subsectors of the industry need be comparable. The upshot of this is that characteristics such as the contribution to production of different inputs or the importance of

---

[6] Apparent excess capacity (at prevailing prices) on existing microwave links and the potential capacity of the proposed domestic satellite bring to mind another analogy with the railroads. In the nineteenth century, uncoordinated investment decisions resulted in three transcontinental rail links, two too many.

economies of scale may depend heavily on the specific activities of the particular company analyzed.

With these conceptual limitations in mind, we turn now to consider statistical relationships which can be used to describe production conditions, and certain data limitations which plague estimation of these.

2. Statistical Relations to be Estimated

Given the conceptual problems just outlined, we must, in describing the technology of the sector, depend upon statistical relationships estimated (at the level of a firm or subsector) in one of three forms:

a) an input-output matrix or sets of activity vectors;

b) a production function;

c) a set of input requirements functions.

Because adequately detailed input-output data are unavailable, we provide estimates only of the latter two types of relationships. (Brief reference to overall features of the production process illustrated by material drawn from existing input-output tables for Canada for the years 1949 and 1961 can be found in Chapter II.)

a) Production functions

The production function summarizes the complex engineering and scientific technology of an industry. At first glance, therefore, it might seem best to use engineering data to estimate technological relationships describing individual production processes, but such information is simply too detailed for our present purposes. We have therefore utilized conventional production functions based on statistical aggregates.

To estimate the production possibilities open to a firm, one requires plant data on various levels of input and the associated levels of output. Assuming that output and inputs are measured in physical terms, it is possible to estimate statistically the parameters of a function representing the production frontier -- that is, showing the maximum output

attainable from efficient use of given inputs. However, when the data are current dollar values rather than physical quantities and refer to a firm rather than a plant, certain problems of estimation arise. We have attempted to meet these difficulties in an appropriate fashion, but we omit discussion of these theoretical issues here.

The functional form yielding the best estimates is the "Cobb-Douglas production function"[7]

$$Y_t = AL_t^{\alpha} K_t^{\beta} \tag{1}$$

where Y, L, and K are measures of output, labour services, and capital services, respectively. The two parameters of primary interest, the elasticity of substitution, σ, and the returns-to-scale parameter, γ, are easy to estimate in this form, since use of the Cobb-Douglas production function implies a constant elasticity of substitution equal to one, and the returns to scale parameter γ is given by $\gamma = \alpha + \beta$.

By many standards, the results obtained by use of this estimation procedure were adequate. Nevertheless, certain inconsistencies between results for various industry subgroups were troubling, and the use of input requirements functions suggested itself as an alternative.

b) <u>Input requirement functions</u>

While a production function estimates the maximum output which can be produced with given inputs, one can also summarize the technology of the production process through a set of functions which indicate, for

---

[7] It is interesting that the simple Cobb-Douglas form yielded good results. Investment in the industry is lumpy and some types of equipment have long lead times between order and delivery. Capital is long-lived, yet different vintages have far different characteristics and efficiencies. For example, equipment used today for switching includes mechanical cross-bar devices first installed in the 1920's and electronic components first introduced a few years ago. However, Solow (1962) has demonstrated that even if the plant technology is one of fixed proportions, a Cobb-Douglas form may frequently give a good approximation to the long run equilibrium conditions of the industry.

a given amount of output, the minimum inputs required to produce that output. These are referred to as input requirement functions, and might be particularly useful in an industry like telecommunications where the level of output is often thought to be primarily determined by factors external to the industry. By turning the production function around, such functions may serve better for purposes of accurate forecasting. And since one of our concerns is to obtain estimates of future demand for inputs, this advantage is important in our analysis of production.

These input requirements functions relate inputs or components of cost to the level of output (with the implicit hypothesis that variations in factor prices are absent or are less important than variations in output for the determination of input levels). They may therefore be thought of simply as decompositions of conventional cost curves.

Such functions may be estimated in the form

$$I_{it} = C_i + \alpha_i V_t + \beta_i M_t + \nu_i D_t + u \qquad (2)$$

where

I_{it} denotes the flow of input i in period t

V_t denotes revenue in period t

M_t denotes the number of messages in period t[8],

D_t denotes an index of technical change at time t.

If there are economies of scale in the use of input i, one would expect the estimated constant term C_i in the above equation to be positive and statistically significant.

---

[8] Both revenue and the number of messages are included in these equations because of the very different impact which increases in demand for local service, as compared to long-distance services, have on input requirements in the short run. Since local service is sold for a fixed fee, if the demand for local calls increases, while the demand for the number of telephones remains constant, there are increased input requirements, but no increase in revenue. When the output measure is local revenue, a short-run increase in telephone calls actually may lead to a decrease in measured labour productivity.

c) Productivity functions

The input requirements functions focus on the question of economies of scale in particular inputs by studying functions relating inputs or costs, one by one, to levels of output. An alternative approach focuses on the issue of factor substitutability by studying functions relating input proportions to input price ratios. Such functions we may call productivity functions.

The reasoning underlying the productivity functions emphasizes the hypothesis that input ratios are determined by the target of profit maximization. For a particular firm, one may have data on its past behaviour in selecting appropriate input mixes to produce projected levels of output. Neglecting technical change, the services of a specific input in any one period can therefore be considered to be related to the expected output of the firm in that period and the price of the input relative to its substitutes in the production process. If output is expected to remain constant, the firm will adjust its mix of input services when the relative prices of these inputs change. As expected or desired output increases, moreover, the amounts required of any input will increase. However, not all adjustments to changes in the relative prices of inputs can be expected to operate instantaneously, for to order new equipment or to find and train new employees may take time. For this reason, it is necessary to include lagged relative prices of inputs in the current demand equation for an input.

Rather than explaining the demand for an input as a function of output and relative prices, we estimate the ratio of the input to output as a function of relative prices. This procedure accords directly with the logic of the cost minimizing model; moreover the ratios of inputs to output (or their inverses) have traditionally been of interest. The ratio of output to labour is average labour productivity, while the ratio of capital to output is a statistic often used in analyzing economic growth. Yet a third ratio of interest is the capital/labour ratio, and this too, we have attempted to explain.

For these aggregates, the functions estimated have been of form:

$$(Q/I)_t^i = \alpha(w/pr)_t^i + \beta(w/pr)_{t-1}^i + \gamma(w/pr)_{t-2}^i + u_i \qquad (3)$$

where the definitions of these variables are as follows:

Q: output measure

I: input measure

w: average wage rate

r: interest rate or rate of return on capital

p: price of investment goods.

The estimation of productivity functions involves an important behavioural issue. The underlying hypothesis, as mentioned above, is that of a profit-maximizing firm facing perfect markets for factor services and for output. In application to a regulated natural monopoly, this hypothesis clearly is inappropriate. An extensive literature treats the issue of production decisions in a regulated firm, and concludes generally that there will be inefficient use of inputs. The reason cited is simply that the effect of regulation

according to a "fair rate of return" on a rate base tends to favour capital accumulation because of its direct favourable impact on permitted revenues.

Were this in fact the case, our estimation of a production function would itself be suspect, since the procedure is grounded upon the assumption of efficient use of inputs. But we believe that the argument is misconceived, overlooking the durability of fixed capital goods. Instead, we argue that within the production decision itself, the situation is one of fixed capital stocks, with decisions only on other variable inputs remaining to be taken, and no reason for these decisions not to lead to efficient us of resources in light of the fixed plant in place. Where distortion arises is at the point of the investment decision, when the quantity of capital to put in place is determined.

Under these circumstances we should expect to have more success estimating a production function, which simply relates observed inputs to observed outputs and entails no explicit maximization hypothesis, or input requirements functions, which relate more detailed input categories observed to be associated with specified output levels, than productivity functions, which entail an explicit cost comparison between the two main input categories as if both were instantaneously variable. This expectation is confirmed in our empirical work -- indeed it was this that led us to question the so-called "Averch-Johnson" effect -- and we therefore do not report upon productivity or factor intensity functions in what follows. So far as we have been able to determine, no conventional relationship between factor intensities and factor price ratios prevails in this sector. Since this result accords with what the above reasoning would suggest should be the case, we take it at face value for now.

d) Data limitations

We have already referred to several conceptual difficulties in the analysis of production relationships within the sector: joint use of common plant prevents identification of separate relations within the separate activities of the sector, lack of physical measures of outputs forces estimation of relationships between constant dollar magnitudes, and engineering data are too detailed for the aggregate relationships we seek. One consequence of these constraints in combination is that it becomes impossible to isolate the sources of possible economies of scale or to separate these from the benefits of increasing utilization of existing overhead plant.

In addition a number of practical limitations on available data have to be noted. In general we have no data on capital services inputs; what we have is data on a capital stock (and frequently only a book value, sometimes depreciated, of that capital stock). Thus at best we require a capacity-utilization index which would allow the conversion of the capital-in-place series to a capital services series. No such series suggests itself, however. Conventional approaches to constructing a capacity-utilization index obviously fail when applied to a network with a dramatic peak load problem and a geographical extent which ensures that much of the network must be idle much of the time. Nor is it easy to assess the effect of "redundant" equipment, installed to keep the probability of "lost calls" below some specified tolerance level, on such a capacity-utilization index. Seeing no alternative, therefore, we employ data on deflated value of plant, book value of plant net of accumulated depreciation,

or book value of plant gross of accumulated depreciation, as a substitute for data on inputs of capital services.

Similarly, except in the case of data for Bell Canada, we have used numbers of employees as a measure of labour input, even though these values do not reflect any change in the number of hours worked per man per year, nor any changes in the skill mix within the labour force. Where possible -- that is, in the relations estimated for Bell Canada data -- we have employed a wage-weighted index of labour hours as measure of labour services.

Thus, to summarize, our investigation of the characteristics of production in the telecommunications sector is based initially upon the use of an overall production function. In principle this single function reflects all relevant aggregate features of the prevailing physical constraints upon the transformation of inputs into outputs. Subsequently we studied input requirements functions and productivity functions separately, the former relating inputs or components of costs to levels of output, the latter relating factor proportions to factor prices. In the next section we describe the results obtained from estimates of such functions for Bell Canada, TCTS, and the telegraph and cable subsectors respectively. Estimation of similar relations for telecommunications services as a whole has not proved feasible thus far.

3. Empirical Results

As indicated above, data availability varied among firms and subsectors of this industry. For the purposes of this chapter, data relating to a single firm -- Bell Canada -- were most complete and appropriate, while data relating to the telephone subsector as a whole were superior to that for the telegraph segment. Three estimates of each function are therefore attempted: one for each major segment, i.e. one for Bell Canada, one for the telephone sector, and one for the telegraph sector.

I. Bell Canada

Bell Canada is the dominant firm in the telecommunications industry. In 1967 it earned 60.5% of all revenue earned by telephone companies and 55% of the revenue earned by telephone and telegraph companies together.[9] The next largest telephone company, B.C. Telephone, is only 1/6 the size of Bell Canada. Canadian National-Canadian Pacific Telecommunications is approximately one-tenth the size of Bell Canada.

a) Production function

Table I shows that there has apparently been considerable change in the productive characteristics of Bell Canada. The capital/labour ratio measured in dollars of net capital stock per man hour increased from

---

[9] This measure considerably understates Bell Canada's actual size, for it has substantial interests in other telephone companies whose revenue is not consolidated with that of Bell: New Brunswick Telephone, Avalon Telephone Company, Northern Telephone, and Maritime Telephone and Telegraph (and a number of smaller telephone companies). Bell owns 100% of Northern Electric, Canada's largest telecommunications equipment manufacturer.

TABLE I

Year	REVENUE: Revenue (Million dollars)	REVENUE: Percent Change in Rev. Yr. to Yr.	CAPITAL: Net Stock (Million dollars)	CAPITAL: Percent Change in K Yr. to Yr.	LABOUR: (000) No. men	LABOUR: (millions) No. Manhrs.	Percent Change Manhrs.	CAP./LABOUR K/No.	CAP./LABOUR K/Hrs.	CAP/REV	REV./LABOUR Rev/No.	REV./LABOUR Rev/Hrs
1952	199.6		564.9		28.7	44.9		19,685	12.58	2.83	6955	4.45
1953	216.0	8.2	620.9	19.9	30.0	45.8	2.0	20,700	13.56	2.87	7200	4.72
1954	234.7	8.7	689.4	11.1	31.1	47.4	3.5	22,165	14.54	2.98	7550	4.95
1955	260.6	11.1	782.8	13.5	34.6	50.9	7.4	22,625	15.38	3.00	7530	5.12
1956	289.7	11.4	889.6	13.6	37.8	54.4	6.9	23,535	16.35	3.07	7665	5.33
1957	320.2	10.5	1017.7	14.4	39.5	57.1	5.0	25,765	17.82	3.18	8105	5.61
1958	343.7	7.3	1167.5	14.7	37.2	57.8	1.2	31,390	20.20	3.40	9235	5.95
1959	373.0	8.5	1314.2	12.6	35.0	56.9	(1.6)	37,550	23.10	3.52	10,655	6.56
1960	398.8	6.9	1463.5	11.4	34.1	55.2	(3.0)	42,920	26.51	3.67	11,695	7.22
1961	426.7	7.0	1601.3	9.4	32.9	53.6	(4.7)	48,670	29.88	3.75	12,910	7.96
1962	470.5	9.3	1734.0	8.2	33.6	52.8	(1.5)	51,605	32.84	3.69	14,005	8.91
1963	503.1	6.9	1876.3	8.2	33.8	53.7	1.7	55,510	34.94	3.73	14,865	9.37
1964	542.5	7.8	2014.0	7.8	34.5	55.1	2.6	58,375	36.55	3.71	15,725	9.85
1965	593.1	9.3	2143.9	6.5	35.5	56.3	1.5	60,390	38.08	3.61	16,710	10.53
1966	648.3	9.3	2285.6	6.6	37.5	57.3	1.8	60,950	38.89	3.53	17,290	11.31
1967	705.0	8.8	2438.7	6.7	36.8	58.4	2.3	66,270	41.76	3.46	19,160	12.08

Data: Revenue - total firm revenue measured in constant 1967 dollars
Labour - Manhours adjusted for the changing mix of employment (see footnote (15) of this chapter for an explanation of the derivation of this series).
Capital - net stock in constant 1967 dollars

Sources: Number of employees: DBS "Telephone Statistics"
Other data: Olley, Memorandum on Productivity, Bell Canada Exhibit No. B-241, Rate Hearings before the Canadian Transport Commission, 1969.

12.58 in 1952 to 41.75 in 1967 (232%).[10] The capital/output ratio increased from 2.83 in 1952 to 3.75 in 1961, then decreased to 3.46 in 1967. Revenue per man hour increased 171% in this same period. The number of man hours increased 30% between 1952 and 1967, although this figure masks a decrease in man hours for the years 1959 through 1962. The capital stock, however, grew some 332% over the same period.

An analysis of the annual rates of change of the revenue, labour, and capital series demonstrates marked differences in the within-decade growth of each series between the 1950's and the 1960's. The annual percentage increases in the measured capital stock averaged 17.7% in the 1952-60 period, and 9.5% in the period 1961 through 1967. In the years 1958-62, while the capital stock increased nearly 40%, the number of manhours worked decreased by 8.7%.

A possible explanation of these trends is offered by Canada's Telephone Industry in Perspective (1969) published by the Telephone Association of Canada:

> Direct Distance Dialing was first introduced in Canada in 1956... In 1958, the first full-scale Canadian installation was completed in Toronto... when dial equipment first took over the job of handling local telephone calls, there were predictions that thousands of operators and other telephone people would be out of work. To the contrary, after a

---

[10] A test suggested by Solow (1957) was used to examine whether this technical change was in fact "neutral" (in the sense of Hicks). Test results suggested that the observed technological progress was capital-augmenting. When using a Cobb-Douglas production function, however, one is unable to distinguish the various forms of factor-augmenting technical change, so that the technical change that did occur can therefore be represented by a simple multiplicative shift.

> temporary halt in the employment curve... improved transmission methods are generating greater demands for service... [11]

Thus the marked differences which appear in the data after 1958 may be due to the heavy capital investment undertaken by Bell Canada prior to 1958 in order to implement a more efficient long distance calling service.[12] This investment was not fully completed until 1958 when customers in Toronto could call other areas by direct-distance-dialing (DDD). The successful implementation of DDD in that year led to a reduction in employment in the three following years and a generally lower rate of growth of labour services in the 1960's.[13]

---

[11] Further evidence on the significance of the 1958 break can be offered. A regression of the form $R = AL^{\alpha}K^{\beta}e^{\gamma t}$ for the period 1952-67 yielded poor results, with high serial correlation in the residuals. Analysis of the residuals of this equation showed that between 1952 and 1957 the residuals are positive, from 1959 to 1964 they are negative and for 1965 through 1967 they once again are positive. Output predicted from the combinations of labour and capital is thus being overestimated in the periods 1952 to 1957 and 1964 to 1967 and underestimated in the middle period.

A division of the period into two sub-periods 1952-58 (direct distance dialing came to Ontario late in 1958), and 1959-67 yielded far better results, with the serial correlation eliminated. Covariance analysis indicated that the subperiod regressions did in fact come from different populations.

While dividing the overall regression into two sub-regressions may have yielded coefficients which are *a priori* more sensible and decreased serial correlation, it is questionable whether this rather arbitrary procedure in fact adds to our knowledge since it provides no explanation for the apparent break in structure.

[12] We are not suggesting that this was the only technological advance in this period. For example linemen became more efficient through the use of crane trucks (telsta trucks) which eliminated climbing of poles.

[13] Before direct distance dialing, an operator answered the call "by plugging one end of a cord circuit into a "jack" (or hole) on the switchboard; and completed the call by plugging the other end of the cord into an outgoing jack". (*Canada's Telephone Industry in Perspective*, p. 43-44).

Table II gives the percentage of station-to-station toll calls dialed by the customer for 10 companies during the period 1952-67. The rise in this percentage from zero reflects the technological change discussed above -- namely, the replacement of operator switching systems by machine switching systems. This percentage of station-to-station toll calls dialed by the customer has been used as a proxy for technological change.

Although this index implies the absence of technological progress over the period 1952-57, it remains the best measure of the pace of technological progress we have found. Attempts to introduce an additional trend to account for improving technology over this early period failed, presumably because any improvements were masked by heavy initial investments not utilized within the period.

To estimate the production function in value-added terms, we deduct from the dependent variable the amounts of raw materials into the production process, and the indirect taxes paid by Bell Canada. Table III gives the percentage of constant-dollar revenue accounted for by the intermediate inputs of raw materials, services, rent and supplies. Also shown in this table is the amount of indirect taxes paid by Bell Canada. As can be seen from the table, raw material requirements fell in this period from 20% of revenue in 1952 to 14% of revenue in 1967, while indirect taxes were a relatively constant share of revenue in this period.[14]

---

[14] Comparison with the input-output results cited earlier shows some discrepancy between the figures here for Bell Canada and the input-output estimates for the communications sector as a whole. Examination of more detailed tables for the U.S. (in 1963) shows that broadcasting is recorded as having very high purchases of raw materials (namely intermediate goods purchased from the service sector called amusements), so that for the sector as a whole the recorded raw materials input may be greater than for telephone alone. Possible differences in recording equipment and construction outlays as expensed raw materials or purchases on capital account may also be involved.

TABLE II

Percentage of station to station toll calls dialed by the customer

Year	Bell	Maritime	New Brunswick	Quebec (exc. Bell)	Manitoba	Sask.	Alberta	B.C.	Okanagan
1952	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0
1957	1.4	0	0	0	0	0	0	0	0
1958	6.0	0	0	0	0	0	0	0	0
1959	10.3	0	0	0	0	0	0	0	0
1960	17.3	0	0	0	0	0	0	0	21.0
1961	23.1	0	0	0	0	0	.9	11.3	53.0
1962	27.0	0	0	0	0	0	2.7	23.4	55.0
1963	31.9	0	0	0	0	0	5.0	35.5	55.0
1964	38.3	10.5	1.2	0	0	7.3	14.5	38.7	56.0
1965	44.1	11.7	12.3	0	11.7	13.2	21.5	39.0	54.0
1966	47.9	12.0	20.3	11.2	16.2	19.6	28.2	39.8	52.0
1967	51.6	22.3	36.5	15.4	20.3	28.1	42.6	39.4	54.0

Source: Data provided by Trans-Canada Telephone Association

TABLE III

Constant Dollar (1967) Raw Materials and Indirect Taxes, as a Percentage of Constant Dollar (1967) Revenue

Year	Raw Materials, Services, Rent, and Supplies (2)	Indirect Taxes (3)	Sum (2)+(3)
1952	20.1	4.6	24.7
1953	19.9	4.6	24.5
1954	20.3	4.6	24.9
1955	21.0	4.6	25.6
1956	22.1	4.5	26.6
1957	20.0	4.6	24.6
1958	20.4	4.6	25.0
1959	19.6	4.7	24.3
1960	19.1	4.9	24.0
1961	18.6	5.2	23.8
1962	16.9	5.0	21.9
1963	17.8	4.9	22.7
1963	16.5	4.8	21.3
1965	16.5	4.7	21.3
1966	15.7	4.9	20.6
1967	14.0	5.0	19.0

Source: Olley, op.cit.

The Cobb-Douglas function finally estimated for Bell Canada is therefore of the form:

$$V_t = AL_t^{\alpha} K_t^{\beta} e^{\gamma D_t} \qquad (4)$$

or

$$\log V_t = A + \alpha \log L_t + \beta \log K_t + \gamma D_t \qquad (5)$$

where

V_t = constant dollar revenue, year t (1967 dollars) (millions)

L_t = manhours adjusted for the changing mix of employment (millions)

K_t = net capital stock year t, adjusted for real depreciation, 1967 dollars (millions)

D_t = percentage of station-to-station toll calls dialed by the customer.[15]

The equation is:

$$\log V_t = \underset{\substack{-.26 \\ (-.81)}}{A} + \underset{\substack{.705 \\ (4.9)}}{\alpha} \log L_t + \underset{\substack{.405 \\ (6.8)}}{\beta} \log K_t + \underset{\substack{.010 \\ (9.5)}}{\gamma} D_t \qquad \begin{array}{ccc} R^2 & DW & S_e \\ .998 & 1.78 & .022 \end{array} \qquad (6)$$

Statistically this equation appears to be thoroughly satisfactory. The coefficient of the technological change term has the appropriate sign and indicates that an increase in the percentage of toll calls handled by the

---

[15] The source for data on R,L,K was Olley, R.E., Productivity Gains in a Public Utility - Bell Canada 1952 to 1967, Canadian Economics Association Meeting, Winnipeg June 1970. A brief description of the procedure used by him to arrive at real dollar estimates is as follows:

a) R: current dollar series adjusted by Bell index of price changes for sub-categories of revenue.

L: actual hours worked adjusted for skill differentials by assuming that the wage for each type of labour measured its skill in relation to the average wage for all labour in the base year 1967. For example if the average wage for all employees was \$3.00/hour, and telephone operators received \$2.00/hour, then it is assumed that operators are 2/3's as skilled as the average labourer and the total hours worked by operators is multiplied by .667.

K; using telephone plant price indexes (1967 base) and age distributions of the net stocks of physical capital in place in each year, a net constant dollar capital stock series is constructed.

The data used for the estimation of equations is marginally different from the data presented in the preceding tables. The regressions utilize the data presented by Olley in June 1970 rather than the 1969 memorandum to the rate hearings.

customer permits the handling of a larger number of calls (and hence increases revenue) without corresponding increases in factor inputs. The coefficient on the variable D_t represents an estimated rate of technical progress of about 4.75% per year, after completion of the initial gestation lag on the heavy initial investment. Its inclusion in the equation substantially improves the results - the percentage of explained variation rises, the degree of serial correlation falls and the coefficients α and β change noticeably. The sum of the coefficients of capital and labour (α and β) or the measure of the economies-of-scale parameter is 1.110 which is significantly greater than unity at the 97.5% level, and implies that a doubling of all inputs would raise output by 110% rather than 100% as would be the case with a constant returns-to-scale function. For comparison with later equations, Appendix I sets out production function estimates for Bell Canada employing either alternative formulations or alternative data series. In order to obtain a somewhat different perspective on the question of returns to scale, we also estimated input requirements functions of the form indicated above. Let us now turn to a discussion of these.

b) Input requirements (cost) functions

Estimating a relationship between output or scale of operation (as measured by revenues and numbers of messages) and various inputs or components of cost, we obtain the results presented in Table IV. As indicated above, we look to the sign and the significance of the intercept term for an indication of the presence or absence of increasing returns to scale. However, the possible multicolinearity introduced by the simultaneous inclusion of two output variables (which generally must change together) may bias the coefficients; therefore we present, in Table V, estimates of the relationship between various inputs and a single measure of output, revenue.

In Table IV, three of the four equations display significantly positive constants. Equation (2) suggests that economies of scale do not occur in the utilization of the services for plant craftsmen who install and repair equipment. Of the six equations in Table V, four exhibit increasing returns: the average number of employees, the average number of adjusted manhours, the average adjusted hours of telephone operators, and average raw material inputs decrease with increased output. Average hours of plant craftsmen (v) and total wages are apparently unrelated to output scale.

Equation (1) suggests that an additional dollar of revenue is linked with .24 of an hour of an operator, while an increase in the number of messages reduces labour requirements, as does an increase in the percentage of toll calls dialed by the customer. The negative relation between messages and operators is difficult to explain, except as a consequence of the interaction between the two measures of output included in the equation. An additional dollar of revenue is associated with .14 hours of plant craftsmen's time, while an additional message is accompanied by .02 hours of such time. The negative correlation between plant craftsmen and the percentage of calls dialed by customers may reflect the decreased maintenance which more modern equipment requires as compared with older plug-in type switchboards. Raw materials, (Equation (vi), Table V) are negatively related to output measures. This result suggests that raw materials represent an overhead input for this sector, for, as we have observed before, much of material inputs apparently flows to construction and maintenance.

TABLE IV

Input Requirements Functions - Bell Canada

	I_{it} =	C	+ aQ_t	+ bM_t	+ CD_t;	$\bar{R}$	DW
(1)	Telephone Operators	115.3 (6.9)	.238 (3.1)	-.016 (-2.5)	-1.43 (-3.3)	.9176	.82
(2)	Plant Craftsmen	9.54 (.63)	.156 (2.3)	.019 (3.2)	-2.11 (-5.4)	.9339	1.31
(3)	Raw Materials, (log)	2.52 (16.)	.0006 (.91)	.0002 (5.8)	-.022* (-5.3)	.9729	1.54
(4)	Number of Employees (log)	2.84 (29.)	.002 (4.7)	.00004 (1.0)	-.019 (-7.3)	.8597	1.15

*time trend rather than CD_t

Wages: total wage bill, deflated by Bell revenue price index - millions of 1967 dollars

Telephone operators: millions of hours (adjusted for changes in the skill level as described in footnote 15, p.23)

Plant craftsmen: millions of hours (adjusted)

Raw materials: millions of constant (1967) dollars

Indirect taxes: millions of constant (1967) dollars

Telephones: thousands of telephones

Q_t: revenue, millions of constant (1967) dollars

M_t: messages, billions

D_t: percentage of toll station-to-station calls dialed by the customer

Sources: Wages, plant craftsmen hours, operator hours, number of telephones, number of messages - Bell Canada Data

Other variables: Olley (C.E.A.) op. cit.

TABLE V

Input Requirements Functions - Bell Canada

I_{it}	=	C	+ aQ_t	+ bD_t ,	R^2	DW
(i)	Wages	-12.5 -(1.5)	.524 (17.)	-2.25 -(8.7)	.997	2.21
(ii)	Number of Employees (log)	2.90 (38.)	.002 (8.1)	-.018 (-7.4)	.8479	1.17
(iii)	Number of Manhours (adjusted)	24.15 (6.8)	.111 (8.0)	-.738 (-6.5)	.8993	1.14
(iv)	Telephone Operators (adjusted hours)	89.5 (5.8)	.103 (1.7)	-1.75 -(3.6)	.8763	.53
(v)	Plant Craftsmen (log) (adjusted hours)	.329 (1.2)	.799 (1) (17.)	-.010 -(9.7)	.9808	1.98
(vi)	Raw Materials	45.78 (18.)	-.073 (-3.1)	6.65 (2) (8.5)	.9899	1.93

(1) Log of revenue

(2) time trend rather than D_t

Employees: number of full-time employees, thousands

Other variables: as given in Table IV

Sources: Number of employees: Bell Canada Data

other variables: as given in Table IV

Cost curves of the kind derived above take output to be the primary determinant of input requirements, omitting mention of factor costs. In theory such requirements functions describe the results obtained by comparing the costs associated with various hypothetical levels of output under the assumption that input prices are unchanged and independent of output levels. In fact, however, substitution of capital for labour is evidently undertaken in periods when wage rates rise rapidly relative to the costs of owning capital goods. Nevertheless, our investigation of productivity or factor intensity functions along the lines suggested in the first section of this chapter failed to reveal any consistent and sensible relationship between factor intensity and relative factor prices. We therefore omit discussion of these relationships, and move on to investigate production conditions in the telephone sector as a whole.

Before doing so, however, we may summarize our results from the analysis of production data for Bell Canada by observing that:

(i) An index of technological change based upon the percentage of station to station toll calls dialed by the customer plays a crucial role in explaining apparently disparate movements in inputs and outputs over the period 1952-1968;

(ii) Use of this index together with data on deflated values of revenue and plant, and wage-weighted labour input measures, enables estimation of a statistically satisfactory aggregate production function of Cobb-Douglas form;

(iii) This production function suggests the presence of increasing returns to scale over Bell's operations as a whole, although these cannot be isolated within any specific sub-activity;

(iv) Estimation of more detailed input requirements functions suggests that these economies of scale are not to be found in the total wage bill, even though average hours of labour input (except plant craftsmen) fall with increasing output, but are accounted for in part by falling raw materials requirements per unit of output.

II. Trans-Canada Telephone System

a) Production function

Sufficient data were available for ten companies, either members or affiliates of the TCTS, to estimate cross-section/time series production functions for the years 1952-67.[16]

The estimated equation was of the form:

$$\log R_t^i = \alpha \log L_t^i + \beta \log K_t^i + \nu D_t^i \; + \gamma_i \; [T_1, \ldots, T_{16}] \qquad (7)$$

where the meaning of these variables is as follows:

R_t^i : revenue in constant 1967 dollars for firm i in year t (Bell Canada price deflator used for all companies);

L_t^i: number of employees (full time);

K_t^i : capital stock (For each company the gross value of capital stock was deflated by a capital stock price index for Bell Canada);

D_t^i : the percentage of station-to-station toll calls dialed by the subscriber;

T_i : dummy variables which take the value of unity for time i and zero elsewhere.

The results for this equation when all ten firms are included (7a) and when all but Bell Canada are included (7b) are given in Table VI.

The results for these two equations (7a) and (7b) are similar to each other, but different from the results obtained in equation (6) for Bell Canada alone. For comparison we tabulate the main features of the three equations.

---

[16] The companies are: Bell Canada, Northern Telephone System, Quebec Telephone, Maritime Telephone and Telegraph, New Brunswick Telephone, Manitoba Telephone, Saskatchewan Telephone, Alberta Telephone, British Columbia Telephone and Okanagan Telephone.

TABLE VI

Production Functions -- Ten Telephone Companies - Individual Firm Data, 1952-1967

$$\log (R_t^i) = \alpha \log L_t^i + \beta \log K_t^i + \gamma D_t + [T_1 \; T_2 \; T_3 \; T_4 \; T_5 \; T_6 \; T_7 \; T_8 \; T_9 \; T_{10} \; T_{11} \; T_{12} \; T_{13} \; T_{14} \; T_{15} \; T_{16} \quad (7)$$

all companies

$$\underset{(10.)}{.484} + \underset{(16.)}{.484} + \underset{(.66)}{.0006} + .08^* + .12^* + .17^* + .17^* + .19 + .16^* + .18^* + .24 + .29 + .34 + .39 + .44 + .46 + .51 + .55 + .59 \quad (7a)$$

$$R^2 = .993$$

all companies except Bell Canada

$$.502 + .438 - \underset{(-.28)}{.0003} + .21 + .26 + .32 + .33 + .35 + .32 + .35 + .41 + .47 + .54 + .58 + .65 + .76 + .73 + .77 + .82 \quad (7b)$$

$$R^2 = .987$$

R_t^i : constant (1967) dollar revenue, firm i, time t (millions)

K_t^i: constant (1967) dollar gross book value of plant, firm i, time t (millions)

L_t^i : number of employees, firm i, time t

D_t^i : percentage of calls dialed by the customer, firm i, time t

T_i : time dummy.

Source: R_t^i, L_t^i, D_t provided by the Trans-Canada Telephone System

K_t^i : DBS Preliminary Report on Large Telephone Systems, 1955-67 Telephone Statistics

*not significant at the 95% confidence level

Equation	α	β	D	$\alpha + \beta$
(6) Bell Canada	.705	.405	.010	1.110
(7a) TCTS with Bell	.484	.484	.0006	.968
(7b) TCTS exc. Bell	.502	.438	-.0003	.940

In particular, where the Bell Canada equation (6) shows increasing returns to scale, both equations (7a) and (7b) exhibit constant returns to scale. Moreover, the coefficient on labour (α) is significantly different as between equation (6) on one hand and equations (7a) and (7b) on the other hand.

This marked -- and somewhat implausible -- difference in the results obtained from estimating production functions for Bell Canada and for member firms of the Trans-Canada Telephone System can perhaps be explained solely by the significant differences in the reliability of the data as between the TCTS regressions and the Bell Canada equation.[17] First, the latter used

---

[17] The possibility that these differences in results might be explained in part by the statistical problem of heteroscedasticity has been checked. The residuals of equations (7a) and (7b) do not suggest evidence of this statistical difficulty. A regression was run on data normalized by the number of residential main subscribers in the company's area. Its results are as follows:

$$\log\,(R_t^i/M_t^i) = A\,\log\,(M_t^i) + \alpha\log\,(L_t^i/M_t^i) + \beta\log\,(K_t^i/M_t^i) + \gamma D_t^i/M_t^i + \delta T$$

$$\begin{array}{ccccc} -.039 & .440 & .553 & .0000006 & .029 \\ (-2.4) & (9.2) & (13.0) & (1.6) & (5.5) \end{array}$$

where R_t^i, L_t^i, K_t^i, D_t are as above and M_t^i is the number of residential main subscribers for firm i at time t, and T denotes a time trend.

These results are for eight firms rather than the ten firms in the above equations since Okanagan Telephone and Alberta Telephone could not provide data on the number of residential main subscribers. Given the difference in sample, these results are therefore not fully comparable to those in equations (7a) and (7b).

as its estimate for labour services a measured total manhours index adjusted for the changing skill mix of the labour inputs. The former use the unadjusted number of full time workers. Because of variations in the work week over this period and the changing mix of skill present in the labour force, the raw employee data is inferior to the adjusted manhours series as a measure of labour services. Secondly, in estimating the production function for Bell Canada alone, a better measure of net capital in constant dollar value was used than in the equations of Table VI, where the gross book value of capital, adjusted by a price series for fixed plant obtained from Bell, was employed. Production functions estimated for Bell Canada using number of employees as the measure of labour services and deflated book value of capital as the measure of capital services in fact showed constant returns to scale (see Appendix I).

Thus, while the sum of $\alpha + \beta$ in the estimation of a production function for the ten companies is not greater than one, it is possible that this sum is a lower bound on the true economies-of-scale measure. Evidence to this effect is found in the fact that the economies to scale estimate for Bell Canada alone is lowered below our earlier estimate by substitution of the less adequate choice of independent variables to which we were restricted by TCTS data. It is therefore possible that slight increasing returns to scale typifies the growth of the large telephone companies -- as appears to be the case for Bell Canada -- in the period 1952-67. For further evidence we again attempt the estimation of input requirements functions.

b) Input requirements functions

The DBS publication Telephone Statistics divides expenses by province into six categories: depreciation, commercial indirect taxes, traffic, repairs, and other expenses. Each of these six categories can be considered a form of input requirement, and requirements functions can be estimated along the lines of the previous section. The simplest explanation for each of these categories was attempted by considering the input involved to be a function of either revenue or the capital stock (or both). The results are set out in Table VII.

All categories, with the exception of depreciation, are highly correlated with revenue. Associated with an additional dollar of revenue are $.081 of commercial cost, $.046 of traffic costs, $.080 of indirect taxes, $.162 of repairs and $.106 of other expenses. Commercial expense is negatively related to the capital stock, and indirect taxes is the only category with a negative trend. From the fact that, of the intercept terms, only that for depreciation is significant, one would conclude that these expense items are simply proportional to output, with no spreading of any overhead component except that on the plant itself.

Thus, in summary, our analysis of the data for the Trans-Canada Telephone System as a whole, while not inconsistent with the earlier analysis for Bell Canada alone (because of differences in the data series available for repression analysis) suggests no direct evidence for the presence of economies of scale, either in the production function or in the more detailed input requirements functions. Nevertheless, with the introduction of regular shifts over time, (which displace our earlier index of technological change) it was possible to estimate a cross-section function explaining differences in company revenues on the basis of capital and labour inputs alone. Substantial regularities in production relationships across the different companies are thus suggested.

TABLE VII

Requirements Functions
Provincial Data, 1963-68

$$I_t^i = A + aR_t^i + bK_t^i + cT + d[P_1 \quad P_2 \quad P_3 \quad P_4 \quad P_5 \quad P_6 \quad P_7 \quad P_8] \; ; \qquad R^2$$

I_t^i =	A	aR_t^i	bK_t^i	cT	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	R^2
Commercial=	.052 (.26)	.081 (7.7)	-.007 (-2.1)	.005 (.13)	+.32	+ 2.5	+ .41	+ 1.4	+ 14.4	+.03*	-.68*	-14*	.999
Traffic =	.195 (.68)	.046 (16.)		.071 (1.4)	+2.5	+ 4.7	+ 2.5	+ 1.0	+ 15.7 +	.34*	+.75	-.23*	.999
Other =	-.040 (.04)	.106 (25.0)		.196 (2.5)	- 1.5	+ 1.2	- .24*	-.15*	- 2.2*	- .06*	+1.5	- .52*	.999
Depreciation =	-2.11 (-2.9)		.070 (31.0)	.176 (1.3)	+ 12.0	- 8.4	- 3.2	- 6.4	-81.8	-2.1	-3.0*	- 1.1*	.999
Taxes (Indirect) =	.28 (.96)	.080 (28.0)		-.218 (-4.1)	- 4.5	- 3.9	-1.9	-2.1	-23.2	-.97	- .89	-.34*	.998
Repairs =	.035 (.05)	.162 (22.0)		.163 (1.2)	+ 2.4	+ 4.2	-1.2*	+3.0	+ 8.4	+.78*	- 1.0	- .66*	.999

*not significant at the 95% confidence level.

All requirements series are in thousands of dollars and are deflated by price index of output (see Olley Memorandum)

R_t^i = constant 1967 revenue company i, time t (current dollar revenue deflated by Bell revenue price index)(thousands)

K_t^i = gross book value of capital deflated by Bell plant price index (thousands)

Sources: All data except price indexes from DBS Telephone Statistics, 1963-68, price indexes from Olley, op .cit.

- P_1: British Columbia
- P_2: Alberta
- P_3: Saskatchewan
- P_4: Manitoba
- P_5: Ontario and Quebec
- P_6: New Brunswick
- P_7: Nova Scotia
- P_8: Prince Edward Island
- P_9: Newfoundland

II. Telegraph Companies

Data for this section are aggregate data for the telegraph and cable industry as published by DBS in Telegraph and Cable Statistics. This publication lists nine companies as belonging to the telegraph industry. Of the nine, two -- Canadian National Telecommunications and Canadian Pacific Telecommunications -- earned 71% of the total revenue for the industry in 1968. In the same year, Canadian Overseas Telecommunications Corporation, the Crown corporation which holds the overseas plant required by the domestic telegraph industry, earned 25.6% of total industry revenue, so that together CNT, CPT and COTC account for 95.8% of industry revenue. The fourth largest company, Eastern Telephone and Telegraph, earned 1.7% of industry revenue in 1968.

CNT and CPT have entered into several joint ventures and reciprocal contracts. For example, they have reciprocally closed many offices in small towns, so that now one firm represents both companies in these towns. (This arrangement explains the sudden large fall between 1960 and 1961 in the number of offices as shown in Table IX.) They have jointly invested in a transcontinental microwave system, and they have jointly purchased 51% of the shares of a computer software company, Computer Sciences Corporation. The statistics available for each company therefore do not represent independent observations on that company's decisions regarding input and output choices. Consequently, industry aggregate data have been used in the calculations which follow.

In the 20 years since 1949, the telegraph industry has undergone a rapid and significant change in its productive activities. In 1949, the industry employed 9,555 persons (of whom 2,731 were telegraph operators),

earned $22,256,000 in revenue, maintained 5,275 offices across Canada and handled 18,099,000 domestically originating telegrams. The number of telegrams sent peaked in 1951 at 19,693,000, and in that year transmission revenue[18] accounted for 54% of the earned revenue.[19] The number of employees reached its maximum in 1953 at 11,618, and the number of telegraph offices a maximum of 5,610 in 1960.

In 1968, this segment of the telecommunications industry handled 8,830,000 telegrams through 1,608 offices employing 1,483 operators, out of a total employment of 8,007. Transmission revenue accounts for 37% of total revenue in 1968 while public and government message service (telegram revenue) falls from 17% of total revenue in 1949 to less than 10% in 1968.

The bulk of 1968 revenue came from non-transmission services. These services include the broad areas of private wire service and switched message subscriber services. Private wire service (dedicated lines) is a "transmission pipe" service for voice, data, and program (radio-TV). Under this service, the customer attaches his own terminal equipment (or equipment rented from CNT/CPT) to a direct line provided by CNT/CPT from point to point.

---

[18] Public and government message, press message, money order, news, telephone service, cable message, scheduled transmission service, broadcast program service, facsimile service, other transmission.

[19] This is an understatement of the true percentage. Before 1961 (CNR) or 1967 (CPR), the rail companies paid a share of the cost of doing business of their telecommunications subsidiary rather than paying revenue for the transmission services which the telegraph companies undertook on behalf of their parent companies.

TABLE IX

Telegraph and Cable Industry, Aggregate Data, 1949-61

Year	Revenue ($000)	Rev, from Non-Trans. Sources ($000)	Employees	Operators	Offices	Telegrams sent (000)
1949	22,257	6691	9555	2731	5288	18,100
1950	23,922	7722	9757	2850	5277	18,519
1951	29,128	9748	10,611	3056	5233	19,693
1952	33,094	11,462	11,272	3224	5256	19,513
*1953	36,920	13,710	11,618	3253	5307	19,041
1954	38,204	16,452	10,629	2785	5015	17,763
1955	39,321	16,626	10,852	2872	5026	17,886
*1956	40,720	14,067	10,833	2881	4926	18,150
1957	44,797	17,397	11,154	2829	5070	17,037
1958	47,634	19,474	10,586	2581	5296	15,875
1959	52,963	24,036	10,586	2265	5427	14,437
1960	58,546	28,520	10,279	2122	5610	13,726
1961	64,054	33,938	9997	2091	3732	13,441
1962	71,379	41,280	10,069	2054	3676	12,834
1963	73,611	45,320	9826	1860	3599	11,930
1964	78,743	47,805	9431	1697	3241	11,717
1965	86,087	52,117	9270	1665	2998	11,533
1966	95,478	60,444	9161	1607	2552	10,327
1967	104,505	65,978	8961	1546	2059	9383
1968	116,667	70,403	8687	1483	1608	8830

*change in format of reporting

Source: DBS "Telegraph and Cable Statistics" (1949-68)

a) Production function

Given the wide variety of services offered, the great change in these services over the period, and the data problems arising from the fact that neither of the major carriers is a separate corporate entity, but rather a division of a much larger enterprise, the obstacles to statistical estimation of the production characteristics of the telegraph and cable industry are rather formidable. In Chapter III it was argued that the completion of the CN-CP transcontinental microwave system in the early sixties was tantamount to the introduction of a set of new services. The revenues generated by these new services were of sufficient magnitude relative to the total of revenues that the implicit assumption, which underlies all regression analysis, of a single structure describing demand throughout the entire sample period was called into serious question. There is a similar problem on the production side. Given the magnitude of the investment involved, it is difficult to argue that completion of the microwave system represented merely a movement on the existing production function. On the contrary, a much more reasonable view is that completion represented the movement to a new production function altogether. If this is the case, then a model which postulates a single production function over the entire period, even with a generous allowance for technological change, will involve a serious misspecification, and the empirical results will probably make little sense.

This has indeed been the case. A conventional Cobb-Douglas production function of the type estimated for telephone, with non-transmission revenues as a percentage of total revenue used as a proxy for technological change, yields results which are weird at best -- among other things, the coefficient for labour is negative -- and resort to ad

hoc, frankly empirical, specifications does not improve matters. As one can see from Table IX, the empirical phenomena that must be reconciled are a total employment which at the end of the period was lower than at the beginning, and an output that over the same period increased more than 1 1/2 times in real terms. This a conventional Cobb-Douglas production function cannot do. Either a more flexible functional form is needed, or, and this the more sensible prescription, the period of observation should be broken up into two subperiods. However, as was noted in Chapter III, there are too few observations for this to be done.

For these reasons, we only present here a function relating total employment in the industry to (deflated) revenues, a quadratic time trend, and the percentage that non-transmission revenues is of total revenue. As noted above, the last variable is taken as a proxy for technological change. The quadratic trend is introduced in order to capture the flow and ebb in employment over the sample period. The primary purpose of this equation, which is given below, is for projection.

$$\underset{(6.8)}{EMP = 10127.} + \underset{(1.1)}{.05\, R_t} + \underset{(.67)}{63.89\, T} - \underset{(-1.5)}{16.83\, T^2} - \underset{(-1.5)}{2254.1\, RA_t} \qquad (19)$$

$R^2 = .943$ $\qquad S_e = 22.3$ $\qquad DW = 2.44$

EMP - total employment (1952-67)

R = total revenue (in thousands; transmission revenues deflated; non-transmission revenues undeflated)

T = time trend.

RA = non-transmission revenue as percentage of total revenue.

n) Input requirements functions

The DBS publication Telegraph and Cable Statistics differentiates between two types of expenses -- maintenance and overhead. Attempts were made to explain each of these two items by either revenue or the capital stock. Revenue gave the better results for maintenance, while the capital stock did better for overhead costs.

$I_t^i =$	a	$+ \; bR_t$	$+ \; cK_t$	$+ \; \delta T$	R^2	DW	
Maintenance=	-13658.6 + (-7.6)	.064 (5.3)		-7.45 (.13)	.977	1.59	(20)
Overhead =	-360.2 (-.94)		+ .030 (5.5)	-297.7 (-2.0)	.941	1.41	(21)

where

Maintenance = maintenance expenditures 1952-67 in thousands

Overhead = overhead expenditures 1952-67 in thousands

R_t = revenue in year t (non-transmission undeflated, transmission revenue deflated)

T = time trend.

The maintenance equation indicates that an increase in maintenance costs of .064 is associated with a $1.00 increase in revenue. While the time trend in the maintenance equation is insignificant, the negative and significant constant term indicates that average maintenance cost increases over time. The overhead equation exhibits an insignificant constant term, but there is a significant negative time trend. Thus, while there appear to be neither economies nor diseconomies of scale for overhead expenditures, unit overhead costs nevertheless decrease over time, due (presumably) to increased technological efficiency.

4. Discussion of Results

What does the foregoing tell us about the characteristics of production in the telecommunications sector? A few strong features are evident.

First, the sector produces services which cannot be stockpiled or held in inventory, so that peak load problems are severe, and lack of adequate capacity means unserviced demand and foregone revenue. None of our analyses -- and no available data -- enables us to assess the costs associated with the distribution of transmitted messages over the day or over the year, although it is obvious that price structures or the introduction of services bringing about a smoother distribution of messages must lower unit costs by spreading overhead plant and labour costs.

Second, as a service industry, production costs are dominated by payments for labour and capital services. Of the raw materials and intermediate goods which are used, few enter the production process directly. Most are related to maintenance.

Third, since the network by which the sector has served its customers involves connections to each household or firm, the sector operates at least in part under conditions of "natural monopoly", meaning that a single firm can offer service at a lower cost at any relevant level of output than any combination of separate firms. Such a feature certainly seems to hold at the local-service level. With regard to long-distance transmission, on the other hand, since this is based upon microwave systems[21] rather than wirelines, the assertion of "natural

[21] In this case there is of course the problem of allocating a scarce public resource -- the frequency spectrum -- but that is a separate issue.

monopoly" is not one which is self-evident. Certainly, there are some markets for which conditions dictate the presence of only a single firm, but there are other markets where "natural oligopoly" might be at least as efficient as "natural monopoly".

This question raises another -- whether, if conditions of natural monopoly (or oligopoly) do in fact prevail in the trunking activity, it is feasible to separate this activity into a service administered by a crown corporation or a "carrier's carrier", such that messages from either a switched local network or a private direct interconnection can be accepted and transmitted. Separation of local collection from trunking would thus be effected in such a way that local calls could be switched to individual processing services, entered to trunking activities if necessary, or switched again to other local destinations. Whether such a separation is feasible rests on technical issues into which we are not competent to delve; whether it would be rational rests in part on the properties of the trunking activity as compared to a local collection activity. Unfortunately, as indicated above, our results provide little guidance on this issue.

It must be emphasized that the question of "natural monopoly" is not identical to the question of returns to scale. With a high fixed charge, one may encounter increasing unit costs (that is, decreasing returns to scale) as output increases, but still have average costs below those attainable by any competition dividing the market. However, our results, as will be noted below, do suggest some conclusions with respect to the issue of returns to scale in utilization of factor inputs.

The trend in the use of factor inputs has been to rising capital intensity, with both capital-labour and capital-output ratios rising over the period. This trend is of course consistent with rising labour productivity and rising wage payments even when numbers of employees are not increasing rapidly. We can note three reasons which could account for this increase in capital intensity:

1. Capital services are becoming cheaper relative to labour;
2. Demand is shifting toward services which can only be provided by more capital-intensive facilities;
3. The lowest cost production techniques are more capital-intensive at higher output levels.

All these reasons are really only one, of course: at the required scale of production, the most efficient way to meet the imposed demands involves introduction of increased amounts of equipment per employee.

Our input requirements functions attempt to capture the impact of changing output levels on factor inputs in various categories. These, and the more elaborate production functions, suggest the presence of increasing returns to scale. In particular, the statistical relations which were estimated for Bell Canada for the period 1952-66 suggest that the firm as a whole was operating under conditions of increasing returns to scale. The analyses of data for eight of the members of the Trans-Canada Telephone Association did not show increasing returns to be present. However, the data used in the latter analyses were not those appropriate to estimation of production or cost functions. In fact when the functions

for Bell Canada were rerun using variables to which we were limited in studying the other members of the Telephone Association, the evidence of increasing returns to scale disappeared. For the telegraph subsector data problems and statistical difficulties connected with the completion of the CN-CP trans-continental microwave network in the early sixties precluded the estimation of production functions at all. Thus, for telegraph and cable, we cannot adduce any statistical evidence with regard to economies of scale at all.

APPENDIX I

This Appendix presents production functions estimated for Bell Canada, but employing alternative data or alternative treatments of the raw materials input. The equation estimated in the text took value-added as the dependent variable, with deflated value of plant and weighted hours of labour input as independent variables. Equally good data are unavailable for other companies, so it is informative to see what difference the various substitutions and modifications might make.

Ideally, a production function should relate value added to primary inputs, and this is the approach we have taken in the text of this chapter. Alternatively, if one believed that inputs of raw material might offer a substitute to primary inputs in production, it might be appropriate to include intermediate goods as a third input, along with the services of labour and capital. The following equation represents an attempt to include raw materials (excluding indirect taxes) in a Cobb-Douglas format, where the variables L, K, D are as in equation (6) of the text, M is constant dollar revenue <u>less</u> constant dollar indirect taxes.

$\log R_t =$	A	$+ \alpha \log L_t$	$+ \beta \log K_t$	$+ \gamma \log M_t$	$+ \delta D_t$	R^2	DW
	-.26	.685	.488	.048	.008	.9984	1.48
	(-.50	(4.5)	(3.7)	(-.25)	(7.9)		

As can be seen from this equation, the coefficient γ, the raw materials coefficient, is insignificant, while the coefficients for labour and capital, α and β respectively, are little changed from their values in equation (6). Thus we conclude that the use of value added as a dependent

variable is more appropriate than the inclusion of raw materials as a third input factor, substitutable for the others.

In some cases we lack data on raw materials in any case. It is therefore of interest to see the effect of taking gross sales, including the value of intermediate inputs, and indirect taxes, as the dependent variable. The following estimated equation does so.

$\log R_t =$	A	$+ \alpha \log L_t$	$+ \beta \log K_t$	$+ \gamma D_t$	, R^2	DW
	-.15	.662	.457	.008	.9984	1.50
	-(.58)	(5.9)	(9.5)	(9.0)		

All coefficients are significant at the 97.5% level of significance, the coefficients of K, L, D being significant at the 99.95% level. The adjusted R^2 is high. The Durbin-Watson statistic (1.50) indicates that there is some positive serial correlation of the residuals. Again one sees that the coefficients change little from those given in the text, so that one's estimate of the degree of increasing returns to scale remains unaltered. The autocorrelation problem becomes more severe, and the estimated rate of technological progress declines somewhat, as is to be expected when raw materials inputs are a declining function of output.

These two equations above, in conjunction with equation (6) of the text, suggest that raw materials cannot be systematically related to output in a production function for Bell Canada. We interpret this result to be largely a consequence of the rather heterogeneous selection of materials inputs, many only distantly related to any actual production function concept, purchased by the company. (From input-output tables, these would appear to include substantial amounts of gas and oil for fleet operations, business services, and other items not closely linked to operations directly producing revenue.)

While the value-added form is theoretically the one which should be used, we are forced to employ the value of sales form in several equations in the text, simply because of the inability to generate value-added data for companies other than Bell Canada. It is possible that using value of sales as a dependent variable will lead us to detect increasing returns to scale where none actually exist simply because an increasing amount of raw materials input is not taken into account. However, since this bias did not appear in analyzing the different forms for Bell Canada, we feel it unlikely that the use of value of sales rather than value-added data for other companies will lead to a significant bias of this sort.

A further difficulty along the same lines arises because we are forced frequently to use book value as a capital series (whereas for Bell Canada we could draw on constructed measures of deflated value of plant) and number of employees as a labour series (while for Bell Canada we had wage-weighted hours data available).

To test the importance of these differences, the following equation gives the production function coefficients estimated for Bell Canada using the number of employees and the gross book value of capital (adjusted by a fixed plant price index) as the measure of labour and capital services, rather than the data used in the original Bell Canada equation. The result is:

$\log R_t =$	A	$+ \alpha \log L +$	$\beta \log K$	$+ \gamma D$	R^2	DW	
	.322	.448	.520	.008	.9980	1.32	(16)
	(1.4)	(14.0)	(5.3)	(10.0)			

The labour elasticity ($\alpha = .448$) is significantly lower than estimated for Bell in equation (6) ($\alpha = .705$), while the elasticity of output with respect to capital is also significantly different in these two equations. The sum of $\alpha + \beta$ (the measure of economies of scale in this equation (16)) is .968, which is not significantly different from unity. Thus, using the number of employees and gross book value of capital data for Bell leads to an estimated production function showing constant returns to scale. For the reasons outlined above, however, the data which generate this result are inferior to the data which lead to an estimate of increasing returns to scale. We might therefore suspect that measures of the degree of returns to scale from the later equations of this chapter may be biased downwards also.

Finally, one further alternative form for the estimating equation may be useful for forecasting purposes. We have argued that one may think of the sector as responding to anticipated demand in establishing capital stocks, and then having available only some flexibility in labour inputs. If this is a correct model, it then makes sense to interpret the production function as signalling the labour input required to man a given capital stock so as to meet a specified demand imposed from outside the sector. With this view, and particularly to forecast anticipated labour input requirements, one should run the production function with labour (total adjusted hours) as the dependent variable. In this case we obtain the equa

$\text{Log } L_t =$ C	$+ \gamma \log V_t$	$+ \delta \log K_t$	$+ \varepsilon D_t$	R^2	DW
.779	.946	-.267	-.109	.9403	1.55
(2.6)	(4.9)	-(2.0)	-(7.1)		

Relating this form to the original set out in equation (6), we see that the implied coefficients deduced from the present equation deviate substantially from those of equation (6). For projections purposes we shall employ both equations, comparing the results.

References

Allen, R.G.D., Mathematical Analysis for Economists MacMillan & Co., (London 1962)

Arrow, K.J., H.B. Chenery, B. Minhas and R.M. Solow, "Capital Labour Substitution and Economic Efficiency". Rev. Econ. Stat. August 1961.

Balestra, P., and M. Nerlove, "Pooling Cross Section and Time Series Data in the Estimation of a Dynamic Model: The Demand for Natural Gas". Econometrica, July 1966.

Beckmann, M.J., & R. Sato; "Aggregate Production Functions and Types of Technical Progress: A Statistical Analysis." American Economic Review, March 1969.

Diewert, W.E., "An Application of the Shephard Duality Theorem: A Generalized Leontief Production Function", Report 6921, Center for Mathematical Studies in Business and Economics, University of Chicago.

Dhrymes, P.J., "A Comparison of Productivity Behaviour in Manufacturing and Service Industries," Rev. Econ. Stat., February 1963

Eads, G., M. Nerlove, W. Raduchel, "A Long Run Cost Function for the Local Service Airline Industry: An Experiment on Non-Linear Estimation", Discussion Paper No. 55, Harvard Institute of Economic Research, Harvard University.

Fisher, F.M., "The Existence of Aggregate Production Function", Econometrica, May, 1969.

Klein, C.R., "A Textbook of Econometrics", Row, Peterson & Co. (Evanston 1953).

Kuh, E., "The Validity of Cross Sectionally Estimated Behaviour Equations in Time Series Applications", Econometrica, April 1959

Marschak, J., and W.H. Andrews, "Random Simultaneous Equations and the Theory of Production", Econometrica 1944.

Nerlove, M., "Returns to Scale in Electricity Supply", in Measurement in Economics-Studies in Mathematical Economics and Econometrics in Memory of Yehuda Grunfeld, (Stanford University Press, Stanford, 1963)

Nerlove, M., "The Estimation and Identification of Cobb Douglas Production Functions", Rand McNally (Chicago 1965)

Salter, W.E.G., Productivity and Technical Change (Cambridge University Press, 1966)

Solow, R.M., "Technical Change and the Aggregate Production Function" Rev. Econ. Stat. August 1957

Solow, R.M., "Heterogeneous Capital and Smooth Production Functions: An Experimental Study", Econometrica October 1963

Solow, R.M., "Capital, Labor and Income in Manufacturing" in The Behavior of Income Shares, NBER, Studies in Income and Wealth, No. 27, (Princeton University Press, Princeton, 1964)

Westfield, F.M., "Technical Progress and Returns to Sale", Review of Economics and Statistics, November 1966

Wickens, M.R..,"Estimation of the Vintage Cobb-Douglas Production Function for the United States, 1900-1960",Review of Economics & Statistics, May 1970.

Zellner, A., J. Kmenta & J. Dreze. "Specification and Estimation of Cobb-Douglas Production Function Models", Econometrica October 1966.

V. INVESTMENT

1. Introduction

The physical plant of the telecommunications industry[1] has expanded significantly over the period from 1950 to the present. From outlays of 171.7 million 1967 dollars per annum in 1950, total capital expenditures by telephone, telegraph and cable companies on plant and equipment rose to 654 million dollars (1967 base) per year in 1968. Over this period, the average annual rate of growth in investment outlays (measured in constant dollars) has been about 7% for the telephone industry and 9.2% for the telegraph and cable industry, compared to an average annual growth rate of 5.8% for private gross fixed capital formation in the economy as a whole. At this rate of growth in gross fixed capital formation, the industry would double the level of its investment outlays in about 10 years. That is, if the historical rate of growth persisted, in 1980 the demand for investment goods generated by this industry alone would amount to 1.3 billion 1967 dollars. Out of this total investment demand, approximately two-thirds would be for new machinery and equipment such as transmission repeaters, switching equipment, local terminal equipment, or cables. The other third would go toward new construction of buildings and other fixed structures such as antennae, poles, or wave guide towers.

By comparison with national business fixed capital formation (net of residential construction and inventory change), therefore, investment in the telecommunications sector is gaining importance. In 1950 the sector accounted for only 3.2% of total Canadian business investment in non-residential construction, equipment and machinery. This share rose to 6.6% in 1960

---

[1] In this, as in the preceding chapter, the "telecommunication industry" is taken to include the telephone and the telegraph and cable industries only.

and to 7.1% in 1968. While there seems little reason to believe that such a rate of growth of capital investment in this industry could continue indefinitely in the future, capital expenditures on fixed capital stock by the sector may well outpace the rest of the Canadian economy for some time to come. Just how will these outlays grow? What are the factors which determine their movements? What may be the policy implications of the time pattern of investment response to certain key determinants?

In this chapter we attempt to answer these and related questions. First, a brief sketch of the framework within which empirical studies on investment behaviour are commonly conducted is given. Explanations of data available and employed, and discussion of empirical results arising from various model specifications will be presented subsequently in the third and fourth sections. A brief summary completes the chapter.

2. Empirical studies of investment behaviour: a brief sketch

Investment in fixed capital stock is normally undertaken either to increase the capacity of the existing stock or to replace all or part of the stock in order to maintain the efficiency of capital facilities. For convenience, investment undertaken to increase capital stock is frequently referred to as net investment, while that investment undertaken simply to maintain existing capacity is labelled replacement investment. Although empirically it is difficult and often impossible to distinguish these two categories, for analytical purposes it is desirable to make such a distinction since decisions on these two types of investment may involve quite different considerations. In recognition of this, current theories of investment

determination divide into two parts: the treatment of net investment behaviour and the explanation of replacement investment.

The demand for services of capital goods is a derived demand depending on a number of considerations such as current and anticipated output, prices and cost structures, and technological conditions. To meet the demand for any given flow of capital services, firms might rent the use of capital goods from other businesses or, more usually, will maintain their own stock of capital, thus in effect purchasing in a lump the whole stream of future services thrown off by the capital goods. Normally a firm may attempt to maintain a desired (or "equilibrium") level of capital stock in relation to its demand for capital service, or, in other words, to its anticipated output level. (Such behaviour may be particularly characteristic of the highly capital-intensive firms in the telecommunications sector.) Net investment thus takes place as an attempt to adjust the level of stock existing at the beginning of the period to the desired level, and by this reasoning the rate of net investment depends both on the existing and the desired levels of capital stock. The desired level of capital stock itself depends directly on the required flow of capital services and thus indirectly upon technological conditions, relative prices and anticipated levels of output.

In making their investment decisions, all the large telephone and telegraph systems such as Bell Canada, B.C. Telephone, and CN/CP Telecommunications apparently do follow something like this process. Periodically, their commercial departments will estimate, on the basis of field surveys of local exchanges and anticipated business

conditions, future demand for their communications services. From these estimates, the facilities required to handle the estimated demand without deterioration in the quality of service will then be calculated by the engineering departments of the companies. The capital budgeting decisions of the firm will place emphasis on these calculations. The final decision on the additional amount of capital equipment to be acquired will thus be determined largely by an estimate of the increment required to achieve the desired future capacity from the existing level.

If there were no time lag in the completion of investment projects, (and if the year were a sacred unit of time), the annual investment rate would be just equal to the difference between the desired and actual levels of capital stock. However, either as a result of technological and institutional restraints or from economic considerations [11], investment does take time to complete. As mentioned above, anticipating an increase in his demand for capital service, the manager of a company offering telecommunication service must draw up investment plans, estimate possible costs, prepare necessary funds, order equipment, and initiate construction. Even if there is no uncertainty, these activities all take time to complete. For example, the construction period for new equipment varies according to the size of the job, but people in this field suggest that

for automatic switchboards, six months for manual switchboards, nine months for repeaters, three months for new cable on existing pole lines, and two years for a major new pole line. As a result, decisions concerning installation of new capital equipment must normally be made well before the equipment is needed in service. Moreover, uncertainty and considerations of cost relative to

the speed of stock adjustment may in any case lead a firm to investment outlays over more than one period.

In order to allow for the time lags in the investment process, it may be assumed that a current change in the desired level of the capital stock sets in motion a wave of investment outlays stretching into the future. A further change tomorrow would set in motion another such wave partially overlapping the first, and so the process might continue. The investment outlays of a given period, therefore, may be considered a cumulation of acquisitions arising from a whole series of separate decisions taken at different times in the past. Thus, altering our point of view to look back to the determinants of present outlays, rather than forward to the future outlays arising from present decisions, we could postulate a relationship which determined present net investment as a weighted average of past changes in the desired capital stock, the weights representing the fraction of investment allocations actually disbursed over various periods in the future. There are various hypotheses by which one might describe these profiles of actual outlays following a particular investment commitment; we have simply chosen a very flexible form specifying the response coefficients, and will let the data indicate the appropriate coefficient values. Theoretical details of our procedure are set out in Appendix A.

Replacement investment refers to that part of total investment required to maintain the capacity of previously acquired capital stock to produce a flow of capital services in a given period. The need for replacement arises from the fact that capital equipment does not have an unlimited service life; each piece of equipment will have to be replaced

some day by a new one. The amount of replacement required for a particular type of capital equipment is determined by its service life, the rate of utilization, and by the age distribution of the capital equipment, as well as by the total current stock. Replacement may also be due to obsolescence. To a great extent the importance of this factor depends upon the individual company's policies regarding the rate of introduction of technological changes. Thus even if the service life of a capital good is well defined, any satisfactory explanation of replacement will require a complete model. Nevertheless on theoretical grounds, one would expect replacement investment outlays to fluctuate less widely than net investment. Experience suggests that for long-run projections, replacement in any given period can be well approximated by a constant fraction of the capital stock accumulated prior to that period. With a few exceptions,[1] therefore, in most empirical studies on investment behaviour it is assumed that replacement investment is proportional to capital stock. Aside from its simplicity in form and its practicality in empirical research, support for this assumption has been sought on both theoretical[2] and empirical[3] grounds. In view of the above arguments, we

---

[1] See [12] for example.

[2] This hypothesis implies that the time pattern of a new set of replacements generated by an expansion in capacity shows a geometric distribution. See [18], [22], and Griliches [13].

[3] In their cross-section survey, Meyer and Kuh [27] could not find any evidence for the so-called "echo-effect" which, if it exists, implies an alternative hypothesis that replacement investment depends on the age distribution of capital stock. Using time series data, Jorgenson and Stephenson [22] claimed to demonstrate the statistical validity of the hypothesis that replacement investment is proportional to the existing capital stock.

shall adopt as our working hypothesis the assumption that replacement is a constant proportion of the existing capital stock.

Combining net investment with replacement, and adopting a flexible distributed lag function as described above, we can thus express gross investment as a function of current as well as lagged changes in desired capital, lagged net investment, and the capital stock at the beginning of the period.[1]

To estimate such an investment function empirically, we must therefore specify the desired capital stock in terms of observed variables. For purposes of discussion, empirical specifications of desired levels of capital stock can be conveniently grouped into three categories; the technological approach, the financial approach, and the neo-classical approach. These may be summarized briefly as follows:

The technological approach maintains that demand for capital assets is determined by the level of production. At every moment there is an optimum production method, regardless of the interest rate or other input prices. For a given level of output, this optimum production process required a certain amount of capital. Therefore, broadly speaking, the level of desired capital must be in proportion to the scale of production. This approach is usually called the accelerator approach [4, 7, and 8]. In its simplest versions, the accelerator model has been criticized on many counts. It is, however, still one of the most popular models used in investment studies [1, 5], and some have argued that it is particularly appropriate in an explanation of the long-term behaviour of investment, when

---

[1] See equation (5) in Appendix A to this chapter.

short-run variations in cash flows and real costs have less importance. For our primary purpose -- obtaining long term projections -- this may well be the relevant model. Moreover, for several practical reasons, it is likely to perform w`ll in describing the telecommunications industry in particular. Possible reasons for this particular validity of accelerator-type models in describing investment in telecommunications facilities flow from the technical sophistication of the equipment and the fact of the regulatory process governing much of the industry's activities.

As a result of the technical complexity of communications equipment, substantial weight is placed upon the highly developed arts of the communications engineer. Given projected levels and mixes of demands for services, he must determine the desired additional capacity for each category of capital, on the basis of calculations taking into account the distribution of calls and of their durations, tolerable "lost-call rates", peak load distributions, and the like. The computations appear to be oriented toward engineering efficiency, with concern for reliability, accuracy, and availability of service. Considerations of projected or actual input and capital costs may well be subordinated in this analysis.

The fact of regulation leads naturally to an emphasis on high standards of quality -- quite possibly standards of quality which are too high in light of relevant costs -- for two reasons. In part this feature may reflect simply the extremely high standards demanded of the system by some users -- the defense department for example -- but also it probably reflects the natural tendency of a regulated firm to overemphasize the importance of quality while underestimating the costs of maintaining that quality. Such a policy obviously leaves the company less vulnerable to

criticism by users and as an added bonus the extra costs may also lead the regulatory authority to permit higher rates.

In the second place, regulation which assures a "fair rate of return" adequate to attract financial capital evidently reduces the importance of costs of financing or considerations of availability of funds. In the past, regulated companies apparently have not had serious difficulty raising the funds necessary to finance capital expansion. Under these circumstances, cost-of-capital considerations might be expected to be less important as determinants of investment outlays.

Thus one expects the accelerator model to perform well in analysis of investment decisions in the telecommunications sector, and it will be seen in the following sections that it does so. Nevertheless, one should not reject the obvious alternative theories out of hand. Whereas the technological approach largely ignores the cost of capital or supply-of-funds aspect of investment, the financial approach tries to establish that demand for new capital goods is in fact primarily determined by the availability of capital funds. Although investment may be financed by both internal and external sources, some enquiries suggest that there is a strong preference among businessmen for internal financing. Primarily, this preference is due to the fact that businessmen consider outside funds as substantially more expensive and more difficult to obtain than those from internal sources. As a result, internal liquidity considerations may be prime factors in determining the level of desired capital. The major flows of internal funds are profits and depreciation expenses. With widely-used declining balance methods of depreciation, the latter flow is relatively stable since it is essentially a constant fraction of existing capital stock which itself is stable. However, profits are quite different, showing distinct fluctuat-

ions over time. Thus in some cases expected profits may be taken as the major determinant of the level of capital. In this simplified version, the desired level of capital is proportional to the level of expected profits which, as suggested by Grunfeld [15], might (in principle) be represented by the market value of the firm.

A reconciliation of these technological and financial approaches is suggested by Kaldor [25], who postulated that the desired level of capital stock depends linearly on both the level of output and the expected rate of profit.

Many modern theories of investment are based on the classic doctrine that investment decisions, like many other economic decisions, are based on a problem of maximization subject to technological constraints. By incorporating a Cobb-Douglas production function into the classical model of net worth maximization, Jorgenson [17, 18] was able to derive explicitly the condition that the desired level of capital is proportional to the ratio of the level of output measured in current dollars to the implicit rental or "shadow price" of one unit of capital service. Thus he arrived at an estimating form which involved both the product price and the imputed cost of holding capital goods. Equations of this type, and also of the cost-of-capital type described earlier, are estimated below; however, none of these proved as consistently satisfactory as the more technically-oriented accelerator approach. This result, as indicated earlier, is consistent with the expected behaviour of a regulated firm in a sector with a highly sophisticated technological structure, even though production conditions might be described by a smooth production function

such as we have already derived for the telecommunications sector. Precisely in the case of "regulated natural monopolists", the net worth maximization model fails to hold in its conventional form.

Thus, in summary, we view the investment decision as determined by the need to adjust actual capital stocks to desired levels, with these desired levels in turn being almost completely determined simply by estimates of the capacity required to meet demand forecasts, using current equipment, and maintaining conventional quality standards.

3. Data

Three types of data are needed to estimate investment functions of the types described above: a series on investment expenditure by the industry, in constant dollars; a series on stocks of capital measured either in physical units of constant productivity or in constant dollars; and a measure of the desired level of the capital stock. The data which are most complete are those for the telephone industry.

Gross investment includes capital expenditures on both new construction (IVC) and on equipment and machinery (IVE). To obtain a measure in physical terms, each series should be deflated by the appropriate investment goods price index. Capital expenditure series are estimated by DBS from its annual survey of private and public capital expenditures in Canada. These series show outlays slightly greater than those reported directly by the Canadian telephone companies, available since 1963 in Telephone Statistics (DBS Cat. No. 56-203). One would prefer the latter series to the former since actually recorded figures ought to be more accurate than those estimated indirectly. Since this latter series is available only from 1963 on, however, we shall in this study use the estimated data in order to maintain a consistent series throughout the

period under consideration. Since the differences between corresponding values are less than 3%, this discrepancy should not have any statistical significance in our analysis of long-term investment behaviour.

While capital expenditures of the telephone industry are clearly part of total investment spending by this industry, the case with respect to repair and maintenance expenditure (INVR) is not so clear. To the extent that such spending on alterations and modernizations is necessary to maintain the services of old switching and transmitting equipment or structures, repair expenditure is a special type of replacement investment. To the extent that such spending is simply for regular servicing of capital equipment, it, like the wage bill, is part of operating expenses and thus should not be treated as investment. Lacking readily available information on this question, we were unable to disentangle one type from the other. Therefore we tried first to include repair expenditures as part of total investment and then to exclude it.

Price indexes of investment goods for the communications sector, prepared for their future report on the capital flows and stock of this sector, were supplied directly by DBS. In some earlier estimates of the total investment function, an investment-goods deflator constructed from price indexes of fully-and-chiefly-manufactured goods, non-residential construction materials, and wage rates in the construction industry was tried. There appear to be no significant differences in the final results employing the alternative deflators.

As in any production and investment study the choice of a measure of capital stock presents special problems. At any moment, the capital stock of a firm or an industry is supposed to measure the productive capacity of the firm or industry given the current state of the arts and a normal rate of capacity utilization. Ideally, one would wish to measure

capital stock by some physical capacity unit, but in empirical studies one could only hope to have a reasonable dollar measure. We have at least five different measures, none of which is satisfactory.

One measure of the total capital stock of the telephone industry is the book value or cost of telephone plant before depreciation. Considering that much old equipment in the telephone industry (such as open wire and poles installed 40 years ago) is still in service, the original cost of telephone plant may serve as a measure of total capital stock. This seems especially to be a sensible measure in conjunction with the measure of gross investment including repair expenditures. The second measure is the cost of telephone plant net of accumulated depreciation. The third measure, supplied directly by DBS, is constructed from an investment series (in constant dollars) and a straight-line depreciation method under the assumption that the average length of service life is 25 years for telephone equipment and machinery, 50 years for building construction, and 55 years for engineering construction. The fourth measure was constructed by a perpetual inventory method, directly from the 1926-68 investment series in constant dollars with a capital survival curve estimated by Bell Canada and an assumed rate of depreciation or obsolesence at 5% per annum.[1] An alternative version was also constructed by substituting for

---

[1] Setting the initial value of the capital stock in 1926 at zero, and employing the series from 1950 on, amounts to ignoring the value, relative to current technological standards, of all equipment more than 25 years old. The series is comparable to a Solow-type "vintage" capital stock measured relative to the shifting standard provided by current capacity units. Perhaps a preferred interpretation is that as a net capital stock series obtained by accounting first for actual mortality through the survival curve, and then for depreciation or declining value through the exponential weighting factor.

the Bell survival curve the simple exponential survival curves for capital equipment and construction based on DBS estimated average lengths of service life.

While the last two measures of capital stock are in constant (1967 base) dollars, the other three are in current dollars. To convert the first three measures to 1967 dollars, we have used a telephone plant deflator derived by Bell Canada from a 1965 survey of its capital stock. Since this is the only aggregate deflator available for both capital equipment and for structures, and since information is not available to reconstruct separate deflators for the two types of capital stock, we have had to apply the same deflator to both series. If in both the manufacturing of telephone equipment and the construction sector the same rate of technological progress prevails, and if the relative factor prices of both these sectors are more or less the same, then to apply the same deflator to different stocks will not introduce any bias. However, given the fact that the price indexes for the two different categories of investment expenditures do grow at different rates, with that for equipment growing at a lower rate than that for construction, one expects that the stock of equipment is overestimated, relative to structures, in the early part of the period. On these grounds, we also tried using price indexes of investment expenditures on equipment and construction to deflate the DBS equipment stock and construction stock series separately. Although the explanatory power of the resulting equations appeared to be slightly greater, this procedure actually over-estimated both stocks and hence was dropped. DBS in fact apparently applies the same set of price indexes to both components of capital stock.

Output of the telephone industry is measured by the total operating revenue of the industry in constant dollars. There is no comprehensive revenue price index for the whole industry; those employed

here are from Bell Canada. Details of the telephone revenue and the relevant price indexes are explained in the chapter on demand analysis.

Market value of the telephone industry is measured by the sum of market value of common shares and the long-term debt deflated by the GNP deflator. Market value of the common shares is obtained as the product of the book value of stock and the price index of common stock of the telephone industry. Both the book value of the common stock and the long-term debt are reported in Telephone Statistics (DBS 56-203). The price index of common stock is available in Prices and Price Indexes (DBS 62-001 and 501).

We assume that the expected rate of profit is approximated by historically observed rates of return on capital. All the necessary data are reported in Telephone Statistics.

For the Griliches-Wallace model we require a long-term utility bond yield. The series we have used is an average rate based on data obtained from McLeod, Young and Weir Investment Inc. A similar series is also obtained for a Bell Canada long-term bond yield.

To obtain a measure of the desired level of capital stock suitable for a 'neoclassical model" we must calculate a user-cost of capital service from the price of investment goods (q), the tax structure, the cost of capital (r), and the rate of replacement (δ), as well as the rate of capital gain or loss ($\Delta q/q$), by the following equation [18, 22]

$$C = \frac{q}{1-u} \left[(1-u\omega)\delta + r - \frac{\Delta q}{q} \right]$$

where u is the corporation income tax rate, ω the proportion of depreciation deductible for tax purposes. If capital gains are considered as "transitory" then this user cost of capital may be written as

$$C' = \frac{q}{1-u}[(1-u\omega)\delta + r]$$

The corporation tax rate is the ratio between taxes and operating profit before taxes; the proportion of depreciation deductible is measured by the ratio of capital consumption allowances for the telephone industry reported in Taxation Statistics (Department of Revenue, Rv-44) to current depreciation. Current depreciation of the telephone industry as a whole is estimated from current depreciation of the large telephone systems, reported in Telephone Statistics.

There are at least six alternative measures of the cost of capital which are commonly employed in empirical studies [30]. The most appropriate one, according to Modigliani and Miller [30], is the long-term bond yield.[1]

A similar set of data is also available for Bell Canada, mostly from its annual reports, and the rest from Olley's study, as mentioned in the chapter on demand analysis. However, since in the investment series there is no breakdown into new equipment and new construction, it is not possible to estimate an equation for each of these components, nor does the investment expenditure series go back far enough to allow us to construct directly a capital stock as we were able to do for the industry as a whole.

Only very limited data are available for the telegraph and cable industry, primarily because these so-called telegraph companies

---

[1] In addition to this one we have also tried the following three measures a) current earnings yields as measured by the ratio of profits after taxes to the market value of stocks, b) profit rate as measured by the ratio of gross profits to the current value of capital, c) the ratio of book value of net worth to the market value of the firm, none of which is thoroughly satisfactory as a cost-of-capital measure. We report the results only in Appendix B.

do not file public financial reports separate from the railway operations of their parent companies. Until recently their operations were not completely independent of the railway companies which own them, and capital is still advanced according to internal capital budgeting procedures, rather than through any market. The information available in Telegraph and Cable Statistics (DBS 56-201) only enables us to estimate an accelerator model for this portion of the industry. Both capital expenditures on new equipment and construction and repair expenditures in current dollars are reported there. Investment series in constant dollars have been obtained by using DBS capital formation deflators for the communications industry as a whole. The gross cost of fixed plant deflated by the Bell telephone plant deflator has been used as a measure of gross capital, and the deflated cost of fixed plant net of accumulated depreciation as a net stock of capital. Output of the telegraph and cable industry has been measured by operating revenue deflated either by the GNP deflator or by the index of rates for public messages described in the demand analysis of this report.

4. Results

Applying the data discussed above for the period from 1952 to 1966 to the various models summarized in the second section of this chapter, we found, not surprisingly, that the best model specification for both the telephone industry as a whole and for Bell Canada is the accelerator model. For each model we have chosen the distributed lag function which yields the minimum standard error around the regression.[1] The best equations of the accelerator model for the telephone industry as a whole are presented here:

$$(1)\quad IVTD_t = \underset{(3.6)}{107.885} + \underset{(5.0)}{2.238}\, DREVD_{t-1} + \underset{(2.1)}{0.362}\, DIVTD_{t-1} + \underset{(2.5)}{0.034} KT_{t-1} \qquad \underline{2/}$$

$$R^2 = 0.9705 \qquad S = 17.1149 \qquad DW = 3.0184$$

$$(2)\quad IVED_t = 48.839 + 1.809\, DREVD_{t-1} + 0.355\, DIVED_{t-1} + 0.034\, KE_{t-1}$$

$$R^2 = 0.9749 \qquad S = 12.0399 \qquad DW = 2.4210$$

$$(3)\quad IVCD_t = \underset{(2.7)}{61.834} + \underset{(1.7)}{0.472}\, DREVD_{t-1} + \underset{(1.4)}{0.355}\, DIVCD_{t-1} + \underset{(1.3)}{0.030}\, KC_{t-1}$$

$$R^2 = 0.8073 \qquad S = 11.3452 \qquad DW = 2.1622$$

---

[1] See Appendix A. A comparison and the display of the results for all the models are given in Appendix B of this chapter.

[2] The presence of negative serial correlation suggests the possibility that the surprisingly low depreciation coefficient may in fact be biased downward as a result of our model specification failing to reflect completely accurately the capital stock adjustment process, a problem of misspecification that may be difficult to avoid in an annual model. We leave this possible statistical problem aside.

The variables in the above equations are defined as follows:

$IVTD_t$ = capital expenditures on both new equipment and construction by the Canadian telephone industry in millions of 1967 dollars.

$DIVTD_t$ = net investment calculated from an average rate of replacement implied by the total constructed capital stock KT_t.

KT_t = constructed capital stock (telephone plant) for the telephone industry as a whole.

$IVED_t$ = capital expenditures on equipment by the Canadian telephone industry in millions of 1967 dollars.

$DIVED_t$ = net investment in equipment and machinery calculated from an average rate of replacement implied by KE_t.

KE_t = constructed capital stock (equipment and machinery) for the telephone industry as a whole.

$IVCD_t$ = capital expenditures on new construction by the Canadian telephone industry in millions of 1967 dollars.

$DIVCD_t$ = net investment in new construction calculated from an average rate of replacement implied by KC_t.

KC_t = constructed capital stock (construction) for the telephone industry as a whole.

$DREVD_t$ = change in the operating revenue of the Canadian telephone industry in millions of 1967 dollars.

Each of these equations says that current capital expenditure by the telephone industry is predominantly determined by the change in the desired capital as measured by the change in operating revenues of the preceding year, lagged net investment, and the level of existing capital stock at the end of the preceding year. To be more specific, according to equation (1) for example, for each increase in revenue by one million dollars per year in the past year there will be 2.2 million 1967 dollars of additional equipment and construction required this year alone to anticipate the increase in service in the future. Net investment in each of the subsequent years required due to this one million dollar increase in revenue alone will be around one-third of the additional capital expenditure spent in the preceding year. Replacement investment is about 3.4 percent of the existing stock of capital at the end of last year.

Similarly, if we consider capital expenditures on new equipment and machinery alone, then, according to equation (2), there will be 1.8 million 1967 dollars of additional investment required this year for new equipment for every million dollar increase in revenue in the past year. The subsequent net investment incurred will be roughly one-third of the net addition to the capital stock of equipment added in the preceding year. Replacement expenditures for equipment and machinery per year is about 3.4 percent of the existing stock of equipment, a rather low estimate for this category. A similar interpretation can be easily extended to equation (3) for capital expenditures on new contruction.

As we have emphasized in the section discussing the empirical studies of investment behaviour, the response of investment to expected changes in the demand for capital services is distributed over time - that is, the response of investment, gross or net, hinges upon the time elapsed after the changes in the demand for capital services have been anticipated. The time patterns of response of investment to a permanent change in demand for capital services implied in the above equations are given in Table I. In the first column are the lags elapsed after a change in the demand for capital services. Columns 2 to 7 record the response of either net (in the even columns) or gross (in the odd columns) investment corresponding to each of the three distributed-lag functions.

Column 1, for example, gives the proportion of response of net investment in both equipment and construction to a permanent change in demand for capital services. A change in demand for capital results in no change in investment for expansion until one year later. At the end of that period, about 63.8% of the required change in demand for capital will be completed; one year later, another 23.1 percent of the required change will be finished, and so forth. The bulk of the required change in net investment is therefore completed in the second year after a change in dema
for capital has been anticipated. The entire investment project initiated in response to a change in the demand for capital is fully completed in the ninth year after the change has been anticipated; after that, net investment will become zero if no other change occurs.

The proportion of response of gross investment is recorded in the third column of Table I. As may be observed, the peak response (63.8%) is also reached a year after the anticipated change in demand for capital

TABLE I

INVESTMENT RESPONSE*

(Calculated Time Forms of Investment Following a Unit Change in Desired Capital Stocks)

Lag	TOTAL Net Investment	TOTAL Gross Investment	EQUIPMENT Net Investment	EQUIPMENT Gross Invest	CONSTRUCTION Net Investment	CONSTRUCTION Gross Investment
0	0	0	0	0	0	0
1	.6380	.6380	.6449	.6449	.6448	.6448
2	.2309	.2526	.2289	.2510	.2295	.2486
3	.0835	.1132	.0813	.1109	.0806	.1076
4	.0302	.0627	.0289	.0614	.0287	.0574
5	.0108	.0445	.0103	.0439	.0096	.0396
6	.0040	.0376	.0036	.0374	.0041	.0328
7	.0014	.0353	.0014	.0353	.0014	.0314
8	.0006	.0345	.0004	.0346	.0000	.0301
9	.0003	.0342	.0000	.0342	.0000	.0000
10	.0000	.0339	.0000	.0342	.0000	.0000
11	.0000	.0399	.0000	.0339	.0000	.0000
12	.0000	.0339	.0000	.0339	.0000	.0000
13	.0000	.0339	.0000	.0339	.0000	.0000
14	.0000	.0339	.0000	.0339	.0000	.0000
15	.0000	.0339	.0000	.0339	.0000	.0000

*Computed from difference equation solutions of equations (1), (2), (3).

services has been diagnosed; all of this expenditure is for net investment. After that, gross investment is the sum of net investment and replacement investment. Compared with the response of net investment, gross investment will not become zero; instead, it will eventually be equal to replacement investment of the stock of capital required for the increase in demand.

It may be noticed that the time pattern of response of investment in both equipment and construction is the same as that for total investment. Although data used here are not quite comparable to those of other studies, these results seem to corroborate other findings. In using U.S. quarterly data, Jorgenson [18], for example, found that for all regulated industries as a whole, there is no response of investment until the fifth quarter after the change in demand for capital services. Moreover, about 63.3% of the required change is completed by the eighth quarter.

In passing we may also note that the capital/output ratio implied by the distributed-lag function of these investment functions is very close to the historical ratio. The steady-state coefficient of output calculated from the total investment equation is 3.508, compared with an average capital/output ratio of 3.7 for 1952-67 from the DBS measure of capital stock. Even compared with the average capital/output ratio of 3.9 for the same period calculated from the our constructed capital stock, this steady-state coefficient is encouragingly close, suggesting that the distributed lag function implied in the total investment function may be a good approximation to the actual investment process of the telephone industry.

Another interesting point is the consistency between the aggregate equation (1) and the disaggregated equations (2) and (3). Since gross investment on both new equipment and construction is the sum of capital outlays on its two components, one would expect that the corresponding coefficients of these three regressions are compatible. This indeed is the case. For example, the sum of the coefficients of the change in demand for capital services in equations (2) and (3) is 2.281; compared with 2.238, the coefficient from the aggregate equation, the discrepancy is less than 2 percent. Furthermore, the aggregated steady-state coefficient of output from the disaggregated equations is 3.537 which is less than one percent above the coefficient implied in the aggregate equation. This implies that a forecast of total investment expenditures using these disaggregated equations will not be very different from that using aggregate equations, but the distribution of these expenditures between the construction and communications equipment sectors is worth knowing.

Thus far we have only discussed the accelerator model. No doubt one would like to compare the relative performance of this model with all others. A detailed comparison is given in Appendix B to this chapter. For our present purposes a brief summary is sufficient.

In most cases the accelerator model explains investment behaviour better than other models, by more than 30% in terms of the standard error of estimate; it works slightly better than the expected-profit model which in turn is superior to most of the Jorgensonian neoclassical models. Compared with the modified neoclassical models, which allow for separate coefficients on the change in output and the change in the relative price of output to the rental value of capital service, however, the accelerator model

performs less well in terms of the standard error of estimate. This is hardly surprising since these models are extended versions of the accelerator model, with both change in output as the principal explanatory variable, and other variables as well.

Nevertheless, in the modified neoclassical models the coefficients corresponding to changes in the relative price are either insignificant at a 5% level of significance or are implausible in light of the theoretical model. So are the coefficients associated with changes in the desired capital stock, in all except one of the non-accelerator models. From this point of view the accelerator model is overwhelmingly superior.

In addition to these two measures, the accelerator model also yields slightly better (or at least equally good) results from the point of view of the maximum number of significant coefficients associated with changes in the demand for capital services. All indications thus confirm the point we made earlier in the section on the framework of empirical studies, that the straightforward accelerator model is likely to be the best we can do in any aggregate analysis of investment in the telecommunications sector.

Through the period from 1950 to 1968 capital expenditures by Bell Canada account for nearly two-thirds of the capital outlays of the telephone industry; the proportion ranges from a low of 53% in 1953 to a high of 68% in 1961. It is therefore important to estimate the investment function for Bell Canada and to compare the results with those for the whole industry.

As expected, the best model specification for Bell Canada is again the accelerator model. The equation is:

$$\text{(4)} \quad BIVTD = \underset{(2.4)}{51.713} + \underset{(3.7)}{2.386}\ DBREVD_{t-1} + \underset{(3.0)}{0.585}\ DBIVTD_{t-2} + \underset{(1.5)}{0.023}\ BOK_{t-1}$$

$$R^2 = 0.9554 \qquad S = 10.6073 \qquad DW = 2.6717$$

where $BIVTD_t$ is capital expenditure of Bell Canada deflated by the Bell telephone plant deflator; $DBREVD_t$ are the changes in Bell Canada's operating revenues deflated by Bell revenue deflators; $DBIVTD_t$ is net investment calculated from an average rate of replacement implied in Olley's measure of net capital stock for Bell Canada (BOK_t). Compared with the corresponding equation for the telephone industry as a whole, the results are generally in agreement. The Bell coefficient associated with the change in output is larger than that for the industry by about 5%. This may reflect simply the fact that Bell is growing relatively faster than the rest of the firms in this sector; with a rate of growth in Ontario and Quebec above the national average, such a result is hardly surprising. The estimated rate of replacement seems rather low. This result is somewhat unexpected since one might anticipate that, being the leader in this sector, Bell Canada would introduce technological changes at a faster rate to keep its leadership. However, one must be warned that since the capital measure for Bell is not constructed precisely as was our total capital stock series, the coefficients on the stock of capital in equations (1) and (4) are not strictly comparable. (Nor have these equations made adequate allowance for the effects of technical change in any case.)

In comparing this accelerator model with other models from Bell Canada data, we again found it to be preferred, with the general relative

performance of the equations being much the same as in the results for the telephone industry. A display and comparison of various models are given in Appendix B of this chapter.

Up to this point we have only discussed the results for the "telephone industry" which accounted in 1967 for about 95% of total capital expenditures and 92% of total revenues of the telecommunications industry. To the results from the data for the "telegraph and cable industry" we must now turn. As explained in the data section, limitations on available data have restricted us to estimating an accelerator model for the "telegraph industry". However, given the superior performance of the accelerator model in explaining the other 95% of the total capital expenditures by the telecommunications sector, one might expect that this selection is probably to be preferred, even if we had all the required information for alternative models.

The regression equation obtained from the original investment series reported in Telegraph and Cable Statistics is poor on many counts: a negative estimated rate of replacement, insignificant coefficients associated with changes in the desired capital stock, small R^2 (ranging from 0.50 to 0.75) and large standard error of estimate The cause of all these troubles is apparently the abnormally high recorded investment outlays in 1960-64 associated with construction of the Trans-Canada Microwave System (TCMS) by CN/CP Telecommunications. Particularly in 1963 when construction of the system was finished, recorded capital investment jumped to 73.1 million 1967 dollars, more than double the investment outlays of any other year from 1965 to 1968. This jump

may perhaps be simply an accounting aberration; expenditures for a large part of finished construction and/or equipment installed before 1963 for the TCMS may have been paid out in 1963 (when the entire system was completed) and thus recorded as investment outlays in that year. On the other hand, most of the construction work of the TCMS may have been completed in 1963 and thus the bulk of expenditures on construction recorded in that year. In any case one would like to be able to disentangle the outlays for the construction of TCMS from other outlays, or, better still, to reallocate it in an appropriate fashion through the years so investment behaviour for the telegraph industry would not be obscured by the abnormal lump-sum outlays in 1960-64.

Unfortunately, however, this task is not possible without much clerical work in recompiling the necessary information from individual company records. We have tried unsuccessfully to use dummy variables on the 1963 and 1960-64 observations. The best equation has been obtained by eliminating the total 75.3 million 1967 dollar expenditure on TCMS during 1960-64 by CN/CP Telecommunications through a proportional reduction in each of the annual outlays for 1960-1964, and introducing a dummy variable 1963 observation. In terms of the explanatory or predictive power of the estimated equation the improvement as a result of this procedure is overwhelming. The estimated equation is given below:

$$(5) \quad \underset{}{TGI_t} = \underset{(3.8)}{13.323} + \underset{(2.0)}{1.341}\, DRTGD_t + \underset{(.63)}{0.106}\, TGIN_{t-1} + \underset{(1.5)}{0.025}\, KTG_{t-1} + \underset{(5.5)}{26.958}\, DUM$$

$R^2 = 0.8783$ $\quad$ $S = 3.7557$ $\quad$ $DW = 2.2785$

Definitions and sources of variables:

TGI_t = investment expenditures by the telegraph industry deflated by the investment good deflator for the communications sector, excluding estimated construction expenditures on TCMS for 1960-64 proportional to the annual capital outlays for this period.

$DRTGD_t$ =changes in the operating revenues of the telegraph industry deflated by the GNP deflator.

$TGIN_t$ =net investment calculated from an average rate of replacement implied in KTG.

KTG_t =net capital stock as measured by net cost of "telegraph" plant deflated by the Bell telephone plant deflator.

DUM =dummy variable, all values except that for 1963 being zero.

This equation suggests that investment outlays in response to revenue or output changes are somewhat lower in the telegraph component than in the telephone sector, but are completed more quickly. An increase of one dollar per year in revenue taken as an indicator of an increase in demand would, according to this equation, be accompanied by an investment outlay of \$1.34 in the same year, and ultimately by an increase in the capital stock of \$1.50. The fact that this incremental capital-output ratio is significantly less than the observed average capital/output ratio for the telegraph and cable companies as a whole may be interpreted as an indication of substantial overhead capacity which can be taken up as output increases, or perhaps as a reflection of the increasing returns to scale tentatively identified in the production chapter (or, indeed, perhaps simply as a reflection of technical change). This effect may also arise in part because revenue measures have not excluded revenues "attributable" to use of micro

facilities, even though investment outlays on microwave facilities have been eliminated from the investment measures. This bias is not sufficiently great as to alter our interpretation, however. Increased capital utilization as revenues expand, in other words, accounts for the lower incremental capital/output ratios and rising capital productivity.

5. Conclusion

What, then, do we conclude from this analysis of investment outlays? The following results seem worth noting.

> Although many recent studies of investment decisions conclude that a "financial" or "neoclassical" model is the most relevant model specification for many industries we have found that investment expenditure by the telecommunications sector in Canada is best explained by a modified accelerator model. This result is consistent with one's expectations concerning the behaviour of a regulated industry, for the reasons outlined earlier, and is strongly supported by all our analyses of the available data.
>
> For the telephone segment of the industry as a whole, this model indicates that an increase in revenues of one million dollars per annum would be associated with 2.2 million dollars of capital expenditure in the following year, with a subsequent stream of capital outlays continuing

until ultimately a total increase of 3.5 million dollars in the capital stock is attained. The distribution of these outlays over time, with very little response in the current year, about 63% of investment completed in the following year, and virtually all completed within two years, is significant, and consistent with estimates obtained from quarterly data on regulated industries in the U.S.. The fact that the long-run or steady-state coefficient of 3.5 is very close to the observed average capital/output ratio for the industry suggests that growth of the sector has kept pressure upon the capital stock, with no evidence of sustained excess capacity.

Again for the telephone industry as a whole, the distribution of investment outlays to construction, as opposed to machinery and equipment, has remained relatively unchanged over the sample period, with about 2/3 going to machinery and equipment, the remainder to construction. Disaggregated equations estimated for these two components separately are encouragingly consistent, showing the same lag pattern for each category, and summing to the previously estimated coefficients for total outlays.

Data for Bell Canada, which accounts for close to two-thirds of total investment expenditures of the telephone industry, are available, and we have employed these to estimate an equation for Bell Canada investment expenditures alone. The resulting equation shows the same pattern of behaviour, but with a significantly higher incremental capital-output ratio. This result is consistent with the fact that Bell Canada has been growing more rapidly than the sector as a whole, and has been required to invest much more heavily in sophisticated and highly capital-intensive switching and trunking equipment than have many of the smaller firms who make up the balance of the telephone industry.

For the telegraph and cable segment of the telecommunications sector, data are less adequate, but again the same pattern can be seen. Incremental capital/output ratios lower than long-run observed averages suggest more influence of excess capacity in this branch of telecommunications operations, previous heavy investment in overhead facilities permitting output and revenue increases with only moderate increases in additional equipment. Alternatively, the explanation of this result might be sought in the presence of economies of scale or continuing technical change. A somewhat faster completion of investment commitments - possibly for the same reason - appears to be indicated by

our empirical results for this segment of the industry compared to the telephone component.

In conclusion we should perhaps record our conviction that further analysis of investment decisions within this sector would be fruitful, but must be directed at a detailed analysis of activities and equipment, recognizing the durability of the investment goods, and the intrinsic uncertainty surrounding the conditions of its future use; such analysis must take into account the expected profiles of wage payments, capital costs, and maintenance outlays over the economic life of the equipment. Aggregate analysis seems unlikely to carry one further than the present chapter has gone; the next step must certainly be to liik in a more detailed way at the structure of the individual investment decision in a regulated environment, with uncertainty as to future market conditions and little scope for changing the operating characteristics of equipment once in place.

APPENDIX "A"

Given that net investment is required for adjusting existing capital to the desired level, and taking the time lag of the investment process into consideration, we arrive at a stock partial-adjustment model, or the fundamental "flexible accelerator" mechanism. Symbolically this hypothesis may be represented as:

$$K_t - K_{t-1} = (1 - \lambda)\ [K_t^* - K_{t-1}] \qquad 0 < \lambda \leq 1, \tag{1}$$

where K_t is the existing level of capital stock in period t and K_t^* the desired level. The parameter λ provides a measure of the rate of adjustment in investment; a smaller λ means a more rapid adjustment of the capital stock to the desired level. By repeated substitution, this model may be written in the form of a well known Koyck-type distributed lag function, which then reflects that existing capital stock in period t is a (weighted average) function of the current as well as all past levels of desired capital stock. The immediate response in capital stock to one unit of persistent change in the desired level of capital is measured by $(1 - \lambda)$. The subsequent reactions are measured by the term $(1 - \lambda)\lambda^i$, declining geometrically.

This simple stock partial-adjustment model carries a restrictive time pattern of reaction of existing capital stock to the past levels of stocks.[1] To allow for any other possible time pattern of capital

---

[1] Although it has been shown that this time pattern has a meaningful interpretation in terms of economic behaviour [see, for example, Cagan, P.D., "The Monetary Dynamics of Hyperinflation," in Studies in the Quantity Theory of Money, edited by Milton Friedman, University of Chicago Press, 1956], other time patterns of economic behaviour may be more adequate in treating specific problems [see, for example, deLeeuw, F., "The Demand for Capital Goods by Manufacturers: A Study of Quarterly Time Series", Econometrica 30(1962),407-23; and Evans, M.K. "A Study of Industry Investment Decisions", Review of Economics and Statistics 49 (1967), 151-64].

adjustment toward a desired level, one may suppose that the reaction coefficients in new investment over time are simply a sequence of non-negative numbers whose sum is unity. Each member of the sequence, say μ_i, is a measure of the lagged impact of a change in the desired capital stock i years earlier on the current level of capital stock; that the sum is equal to unity implies that an investment project is always completed some time in the future. One way to generate a sequence of reaction coefficients of this type is to use the ratio of two polynomial functions -- that is, a Jorgensonian rational generating function.[2]

Keeping this feature in mind the simple partial stock-adjustment model may be generalized to a hypothesis that net investment (NI) is a distributed lag function of annual changes in the desired capital stock [17,20]

$$NI_t = \frac{\beta(L)}{\nu(L)} [K^*_t - K^*_{t-1}] \tag{2}$$

where $\beta(L)$ and $\nu(L)$ are polynomials in the lag operator L,

$$\beta(L) = \beta_0 + \beta_1 L + \beta_2 L^2 + \ldots$$

$$\nu(L) = 1 + \nu_1 L + \nu_2 L^2 \ldots$$

[2] Solow [31] proposed a Pascal distribution lag function in which the weights or reaction coefficients assigned corresponded to the Pascal probability distribution. This proposal was generalized by Jorgenson [20] to a class of rational distributed lag functions; each member is a distinct, distributed-lag function depending on the ratio of two polynomials.

Let RI be replacement investment, and δ the (constant) rate of replacement; then we get the simple equation:

$$RI_t = \delta K_{t-1} \tag{3}$$

Observing that net investment is identical to that part of gross investment in excess of replacement, we may write gross investment as a function of changes in current and previous desired levels of capital and of the actual capital stock at the beginning of the period.

$$I_t \equiv NI_t + RI_t = \frac{\beta(L)}{\nu(L)} [K^*_t - K^*_{t-1}] + \delta K_{t-1} \tag{4}$$

To be able to estimate this investment function empirically we must do three things: express the desired capital stock in terms of observed variables, choose the order of the polynomials $\beta(L)$ and $\nu(L)$, and add to the above investment function a random error term. For the last task, we employ the commonly adopted assumption that the error term U_t is distributed independently over time with zero mean and constant variance:[3]

$$E(U_t) = 0 \qquad t = 1,\dots,T$$

$$E(U_t\, U_{t-i}) \quad \begin{matrix} \sigma^2 \text{ for } i = 0 \\ 0 \text{ for } i \neq 0 \end{matrix}$$

The criterion for choice of the orders of the polynomials $\beta(L)$ and $\nu(L)$ is not well established. In this study we shall adopt Jorgenson's suggestion to choose the combination of $\beta(L)$ and $\nu(L)$ such that the standard error of estimation is smallest subject to the constraint that the order for both the polynomials is at most three.

---

[3] Most empirical studies on investment adopted this specification. Some justification is given by Grunfeld [14], and Jorgenson and Siebert [21] among others.

APPENDIX B

To compare the alternative models of capital investment, we have chosen from the regressions fitted for the period 1952 to 1967 the best equation for each model under the criterion suggested in the text of this chapter. The results are presented in Tables I - VI.[1] Definitions of the variables are given at the bottom of each table, along with the t-statistics of each coefficient. The Durbin-Watson statistic (DW), the coefficient of determination (R^2), and the standard error (S) are also given under each regression. In Table I, for example, there are twelve regressions fitted to capital expenditures by the telephone industry, each representing, for one model, the best distributed lag function between investment and changes in some measure of the desired level of capital.

---

[1] Results in Tables I to IV are the fitted regressions on capital expenditure on new equipment and construction only; stocks of capital are constructed capital stocks for the Canadian telephone industry, and Olley's adjusted net capital stock for Bell Canada. Results for investment including repair expenditures with gross cost of telephone plant, and for capital expenditures on new equipment and construction with net cost of telephone plant, as measures of stock of capital exhibit a similar pattern among various models, and thus will not be reported here.

Table I

Capital Expenditure on New Equipment and Construction by the Canadian Telephone Industry

1. Accelerator Model

$$IVTD_t = \underset{(3.6)}{107.885} + \underset{(5.0)}{2.238}\ DREVD_{t-1} + \underset{(2.1)}{0.362}\ DIVTD_{t-1} + \underset{(2.5)}{0.034}\ KT_{t-1}$$

$R^2 = 0.9705$ $S = 17.1149$ $DW = 3.0184$

2. Expected Profit Model

$$IVTD_t = \underset{(3.4)}{144.631} - \underset{(-3.4)}{0.252}\ DMKD_t - \underset{(-1.6)}{0.180}\ DMKD_{t-1} + \underset{(0.95)}{0.234}\ DIVTD_{t-1} + \underset{(6.5)}{0.112}\ KT_{t-1}$$

$R^2 = 0.9603$ $S = 21.0566$ $DW = 2.2257$

3. Neoclassical Model 1 -- with earning yields as cost of capital (without capital gains)

$$IVTD_t = \underset{(3.2)}{136.583} + \underset{(3.5)}{0.031}\ DNE1_t + \underset{(0.57)}{0.142}\ DIVTD_{t-1} + \underset{(6.8)}{0.084}\ KT_{t-1}$$

$R^2 = 0.9519$ $S = 21.8472$ $DW = 1.9705$

4. Neoclassical Model 2 -- with earning yields as cost of capital (with capital gains)

$$IVTD_t = \underset{(1.5)}{85.755} - \underset{(-1.1)}{0.003}\ DNE2_t + \underset{(1.2)}{0.429}\ DIVTD_{t-1} + \underset{(4.7)}{0.086}\ KT_{t-1}$$

$R^2 = 0.9002$ $S = 31.4495$ $DW = 1.5728$

5. Neoclassical Model 3 -- with profit rate as cost of capital (without capital gains)

$$IVTD_t = \underset{(1.4)}{81.977} + \underset{(0.45)}{0.030}\ DNE3_{t-2} + \underset{(2.4)}{0.805}\ DIVTD_{t-1} - \underset{(-1.5)}{0.516}\ DIVTD_{t-2} + \underset{(4.8)}{0.092}\ KT_{t-1}$$

$R^2 = 0.9121$ $S = 31.3174$ $DW = 2.1397$

6. Neoclassical Model 4 -- with profit rate as cost of capital (with capital gains)

$$IVTD_t = \underset{(1.8)}{108.744} - \underset{(-1.5)}{0.007}\ DNE4_t + \underset{(0.83)}{0.299}\ DIVTD_{t-1} + \underset{(5.0)}{0.089}\ KT_{t-1}$$

$R^2 = 0.9087$ $S = 30.0855$ $DW = 1.8081$

7. Neoclassical Model 5 -- with ratio of net-worth to market value as cost of capital (without capital gains)

$$IVTD_t = \underset{(1.7)}{90.635} - \underset{(-0.74)}{0.141}\ DNE5_{t-2} + \underset{(2.3)}{0.783}\ DIVTD_{t-1} - \underset{(-1.1)}{0.419}\ DIVTD_{t-2} + \underset{(4.5)}{0.089}\ KT_{t-1}$$

$R^2 = 0.9155$ $S = 30.6935$ $DW = 2.2036$

8. Neoclassical Model 6 -- with ratio of networth to market value as cost of capital (with capital gains)

$$IVTD_t = \underset{(1.7)}{90.430} - \underset{(-0.77)}{0.161}\ DNE6_{t-2} + \underset{(2.4)}{0.789}\ DIVTD_{t-1} - \underset{(-1.2)}{0.422}\ DIVTD_{t-2} + \underset{(4.6)}{0.089}\ KT_{t-1}$$

$R^2 = 0.9161$ $S = 30.5858$ $DW = 2.3109$

9. Neoclassical Model 7 -- with utility bond yield as cost of capital (without capital gains)

$$IVTD_t = \underset{(2.1)}{127.348} + \underset{(1.2)}{0.019}\ DNE7_t + \underset{(1.0)}{0.441}\ DIVTD_{t-1} - \underset{(-.74)}{0.276}\ DIVTD_{t-2} + \underset{(4.8)}{0.088}KT_{t-1}$$

$R^2 = 0.9245$ $S = 29.0142$ $DW = 2.2368$

10. Neoclassical Model 8 -- with utility bond yield as cost of capital (with capital gains)

$$IVTD_t = \underset{(1.9)}{128.540} - \underset{(-1.4)}{0.006}\ DNE8_t - \underset{(-0.43)}{0.002}\ DNE8_{t-1} + \underset{(1.4)}{0.576}\ DIVTD_{t-1} - \underset{(-1.5)}{0.509}\ DIVTD_{t-2}$$

$$+ \underset{(4.9)}{0.100}\ KT_{t-1}$$

$R^2 = 0.9301$ $S = 29.8474$ $DW = 2.3770$

11. Neoclassical Model 9 -- Neoclassical Model 7 with separate coefficients for relative price and output

$$IVTD_t = \underset{(5.0)}{109.884} - \underset{(-2.2)}{21.156}\, DRP_t - \underset{(-1.2)}{12.680}\, DRP_{t-1} + \underset{(4.7)}{2.084}\, DREVD_{t-1} + \underset{(2.6)}{1.275}\, DREVD_{t-2}$$

$$+ \underset{(2.0)}{0.307} DIVTD_{t-2} + \underset{(0.98)}{0.015}\, KT_{t-1}$$

$R^2 = 0.9904$ $S = 11.9692$ $DW = 2.6776$

12. Neoclassical Model 10 -- Neoclassical model 8 with separate coefficients for relative price and output

$$IVTD_t = \underset{(3.9)}{116.896} - \underset{(-0.64)}{0.671}\, DRPP_t + \underset{(5.3)}{2.843}\, DREVD_{t-1} + \underset{(1.8)}{0.378}\, DIVTD_{t-2} + \underset{(0.88)}{0.018}\, KT_{t-1}$$

$R^2 = 0.9730$ $S = 17.3485$ $DW = 2.8078$

Definitions of the variables:

$IVTD_t$ = capital expenditures on both new equipment and construction by the Canadian telephone industry in millions of 1967 dollars.

$DREVD_t$ = change in the operating revenue of the Canadian telephone industry in millions of 1967 dollars.

$DMKD_t$ = change in the market value of the Canadian telephone industry in millions of 1967 dollars

$DNEi_t$ = change in the output-rental ratio of this industry in i^{th} measure of cost of capital

DRP = change in the relative price of output to capital service excluding capital gains

$DRPP_t$ = DRP with capital gains included

$DIVTD_t$ = net investment calculated from an average rate of replacement implied by the total vintage capital stock KT_t

KT_t = Constructed capital stock (telephone plant) for the telephone industry.

Table II

Capital Expenditure on New Equipment by the Canadian Telephone Industry

1. Accelerator Model

$$IVED_t = \underset{(2.9)}{48.839} + \underset{(5.7)}{1.809}\ DREVD_{t-1} + \underset{(2.0)}{0.355}\ DIVED_{t-1} + \underset{(2.1)}{0.034}\ KE_{t-1}$$

$R^2 = 0.9749$ $S = 12.0399$ $DW = 2.4210$

2. Expected Profit Model

$$IVED_t = \underset{(3.2)}{109.429} - \underset{(-1.5)}{0.167}\ DMKD_{t-1} - \underset{(-1.1)}{0.136}\ DMKD_{t-2} - \underset{(-1.6)}{0.615}\ DIVED_{t-2} + \underset{(5.7)}{0.187}\ KE_{t-1}$$

$R^2 = 0.9135$ $S = 16.7196$ $DW = 1.7419$

3. Neoclassical Model 1 -- with earning yields as cost of capital (without capital gains)

$$IVED_t = \underset{(2.8)}{68.670} + \underset{(1.7)}{0.015}\ DNE1_t + \underset{(0.42)}{0.007}\ DNE1_{t-1} - \underset{(-1.8)}{0.034}\ DNE1_{t-2} + \underset{(1.2)}{0.358}\ DIVED_{t-1}$$

$$+ \underset{(4.3)}{0.084}\ KE_{t-1}$$

$R^2 = 0.9677$ $S = 15.4982$ $DW = 2.0080$

4. Neoclassical Model 2 -- with earnings yields as cost of capital (with capital gains)

$$IVED_t = \underset{(1.6)}{48.887} + \underset{(0.048)}{0.00002}\ DNE2_{t-2} + \underset{(2.5)}{0.853}\ DIVED_{t-1} - \underset{(-2.1)}{0.781}\ DIVED_{t-2} + \underset{(5.1)}{0.121}\ KE_{t-1}$$

$R^2 = 0.9331$ $S = 20.8561$ $DW = 1.8751$

5. Neoclassical Model 3 -- with profit rate as cost of capital (without capital gains)

$$IVED_t = \underset{(1.7)}{47.067} + \underset{(0.98)}{0.040}\ DNE3_{t-2} + \underset{(1.6)}{0.616}\ DIVED_{t-1} - \underset{(-2.0)}{0.664}\ DIVED_{t-2} + \underset{(5.5)}{0.125}\ KE_{t-1}$$

$R^2 = 0.9403$ $S = 19.7115$ $DW = 1.6017$

6. Neoclassical Model 4 -- with profit rate as cost of capital (with capital gains)

$$IVED_t = \underset{(1.7)}{49.268} - \underset{(-0.62)}{0.0002}\ DNE4_t + \underset{(2.6)}{0.838}\ DIVED_{t-1} - \underset{(-2.3)}{0.740}\ DIVED_{t-2} + \underset{(5.0)}{0.119}\ KE_{t-1}$$

$R^2 = 0.9362$ $S = 20.3727$ $DW = 2.0932$

7. Neoclassical Model 5 -- with ratio of net worth to market value as cost of capital (without capital gains)

$$IVED_t = \underset{(1.7)}{51.676} - \underset{(-0.29)}{0.037}\ DNE5_{t-2} + \underset{(2.6)}{0.845}\ DIVED_{t-1} - \underset{(-2.4)}{0.777}\ DIVED_{t-2} + \underset{(5.1)}{0.121}\ KE_{t-1}$$

$R^2 = 0.9338$ $S = 20.7478$ $DW = 1.8596$

8. Neoclassical Model 6 -- with ratio of net worth to market value as cost of capital (with capital gains)

$$IVED_t = \underset{(1.7)}{52.600} - \underset{(-0.45)}{0.060}\ DNE6_{t-2} + \underset{(2.6)}{0.848}\ DIVED_{t-1} - \underset{(-2.4)}{0.775}\ DIVED_{t-2} + \underset{(5.1)}{0.121}\ KE_{t-1}$$

$R^2 = 0.9347$ $S = 20.6051$ $DW = 1.8875$

9. Neoclassical Model 7 -- with utility bond yield as cost of capital (without capital gains)

$$IVED_t = \underset{(2.4)}{66.532} + \underset{(1.6)}{0.013}\ DNE7_t + \underset{(1.8)}{0.585}\ DIVED_{t-1} - \underset{(-1.8)}{0.564}\ DIVED_{t-2} + \underset{(5.2)}{0.112}\ KE_{t-1}$$

$R^2 = 0.9496$ $S = 18.1081$ $DW = 2.2607$

10. Neoclassical Model 8 -- with utility bond yield as cost of capital (with capital gains)

$$IVED_t = \underset{(2.0)}{65.199} - \underset{(-1.4)}{0.004}\ DNE8_t - \underset{(-0.15)}{0.0004}\ DNE8_{t-1} + \underset{(1.8)}{0.678}\ DIVED_{t-1} - \underset{(-2.6)}{0.770}\ DIVED_{t-2} + \underset{(5.3)}{0.128}\ KE_{t-1}$$

$R^2 = 0.9505$ $S = 19.1763$ $DW = 2.2448$

11. Neoclassical Model 9 -- Neoclassical Model 7 with separate coefficients for relative price and output

$$IVED_t = \underset{(2.5)}{42.379} - \underset{(-1.3)}{11.313}\ DRP_t + \underset{(5.5)}{1.730}\ DREVD_{t-1} + \underset{(2.2)}{0.384}\ DIVED_{t-1} + \underset{(2.3)}{0.037}\ KE_{t-1}$$

$R^2 = 0.9791$ $S = 11.6514$ $DW = 2.2682$

12. Neoclassical Model 10 -- Neoclassical Model 8 with separate coefficients for relative price and output

$$IVED_t = \underset{(3.0)}{51.977} - \underset{(-0.96)}{0.666}\ DRPP + \underset{(5.3)}{1.729}\ DREVED_{t-1} + \underset{(1.7)}{0.318}\ DIVED_{t-1} + \underset{(2.8)}{0.039}\ KE_{t-1}$$

$$R^2 = 0.9775 \qquad S = 12.0939 \qquad DW = 2.5495$$

Definitions of the variables:

$IVED_t$ = capital expenditures on equipment by the Canadian telephone industry in millions of 1967 dollars

$$\left.\begin{array}{l} DREVD_t \\ DMKD_t \\ DNEi_t \\ DRP_t \\ DRPP_t \end{array}\right\} \quad \text{See the definitions in Table I}$$

$DIVED_t$ = net investment in equipment and machinery calculated from an average rate of replacement implied by KE_t.

KE_t = constructed capital stock (equipment and machinery) for the telephone industry.

Table III

Capital Expenditure on Construction by the Canadian Telephone Industry

1. Accelerator Model

$$IVCD_t = 61.834 + 0.472\ DREVD_{t-1} + 0.355\ DIVCD_{t-1} + 0.030\ KC_{t-1}$$
(2.7) (1.7) (1.4) (1.3)

$R^2 = 0.8073$ $S = 11.3452$ $DW = 2.1622$

2. Expected Profit Model

$$IVCD_t = 69.053 - 0.052DMKD_t - 0.078\ DMKD_{t-1} + 0.245\ DIVCD_{t-1} + 0.083\ KC_{t-1}$$
(2.8) (-1.3) (-1.3) (.87) (4.4)

$R^2 = 0.8237$ $S = 11.5103$ $DW = 2.2100$

3. Neoclassical Model 1 -- with earning yields as cost of capital (without capital gains)

$$IVCD_t = 45.748 + 0.028\ DNE1_t + 01355\ DIVCD_{t-1} + 0.062\ KC_{t-1}$$
(2.0) (1.4) (1.3) (4.5)

$R^2 = 0.7889$ $S = 11.8768$ $DW = 2.0018$

4. Neoclassical Model 2 -- with earning yields as cost o- capital (with capital gains)

$$IVCD_t = 51.842 - 0.0005\ DNE2_t + 0.410\ DIVCD_{t-1} + 0.062\ KC_{t-1}$$
(1.9) (-0.44) (1.3) (4.1)

$R^2 = 0.7505$ $S = 12.9110$ $DW = 1.8716$

5. Neoclassical Model 3 -- with profit rate as cost of capital (without capital gains)

$$IVCD_t = 43.619 + 0.009\ DNE3_{t-2} + 0.474\ DIVCD_{t-1} + 0.061\ KC_{t-1}$$
(1.7) (0.32) (1.7) (4.0)

$R^2 = 0.7478$ $S = 12.9798$ $DW = 1.8020$

6. Neoclassical Model 4 -- with profit rate as cost of capital (with capital gains)

$$IVCD_t = \underset{(1.7)}{54.861} - \underset{(-0.45)}{0.0009}\ DNE4_t + \underset{(1.0)}{0.374}\ DIVCD_{t-1} + \underset{(4.1)}{0.062}\ KC_{t-1}$$

$R^2 = 0.7505$ $\quad S = 12.9102$ $\quad DW = 1.8826$

7. Neoclassical Model 5 -- with ratio of net worth to market value as cost of capital (without capital gains)

$$IVCD_t = \underset{(1.2)}{39.996} - \underset{(-0.27)}{0.022}\ DNE5_t + \underset{(1.4)}{0.545}\ DIVCD_{t-1} + \underset{(4.0)}{0.063}\ KC_{t-1}$$

$R^2 = 0.7471$ $\quad S = 12.9986$ $\quad DW = 1.7535$

8. Neoclassical Model 6 -- with ratio of net worth to market value as cost of capital (with capital gains)

$$IVCD_t = \underset{(1.6)}{42.1242} - \underset{(-0.36)}{0.027}\ DNE6_t + \underset{(1.7)}{0.521}\ DIVCD_{t-1} + \underset{(4.1)}{0.063}\ KC_{t-1}$$

$R^2 = 0.7487$ $\quad S = 12.9565$ $\quad DW = 1.7755$

9. Neoclassical Model 7 -- with utility bond yield as cost of capital (without capital gains)

$$IVCD_t = \underset{(1.7)}{34.842} - \underset{(-2.1)}{0.030}\ DNE7_t + \underset{(2.6)}{0.646}\ DIVCD_{t-1} + \underset{(5.2)}{0.065}\ KC_{t-1}$$

$R^2 = 0.8300$ $\quad S = 10.6574$ $\quad DW = 1.7365$

10. Neoclassical Model 8 -- with utility bond yield as cost of capital (with capital gains)

$$IVCD_t = \underset{(2.1)}{53.470} - \underset{(-0.89)}{0.001}\ DNE8_t + \underset{(1.4)}{0.395}\ DIVCD_{t-1} + \underset{(4.2)}{0.061}\ KC_{t-1}$$

$R^2 = 0.7655$ $\quad S = 12.5162$ $\quad DW = 1.9438$

11. Neoclassical Model 9 -- Neoclassical Model 7 with separate coefficients for relative price and output

$$IVCD_t = \underset{(3.7)}{74.937} - \underset{(-1.7)}{12.744}\ DRP_t - \underset{(-2.3)}{17.690}\ DRP_{t-2} + \underset{(3.0)}{0.736}\ DREVD_{t-1} + \underset{(0.79)}{1.200}\ DIVCD_{t-2}$$

$$+\underset{(0.48)}{0.010}\ KC_{t-1}$$

$R^2 = 0.8921$ $\quad S = 9.62886$ $\quad DW = 2.6216$

12. Neoclassical Model 10 -- Neoclassical Model 8 with separate coefficients for relative price and output

$$IVCD_t = \underset{(3.4)}{83.607} - \underset{(-1.5)}{1.055}\ DRPP_t - \underset{(-1.7)}{1.172}\ DRPP_{t-1} + \underset{(2.0)}{0.494}\ DREVD + \underset{(0.53)}{0.163}\ DIVCD_{t-2}$$

$$+ \underset{(0.78)}{0.021}\ KC_{t-1}$$

$R^2 = 0.8430$ $S = 11.6131$ $DW = 2.0269$

Definitions of the variables:

$IVCD_t$ = capital expenditures on new construction by the Canadian telephone industry in millions of 1967 dollars

$$\left.\begin{array}{l} DREVD_t \\ DMKD_t \\ DNEi_t \\ DRP \\ DRPP \end{array}\right\} \quad \text{See the definitions in Table I}$$

$DIVCD_t$ = net investment in new construction calculated from an average rate of replacement implied by KC_t

KC_t = constructed capital stock (construction) for the telephone industry.

6. Neoclassical Model 4 -- with profit rate as cost of capital (with capital gains)

$$BIVTD_t = \underset{(2.1)}{50.7069} - \underset{(-1.9)}{0.004}\ BDNE4_t + \underset{(1.5)}{0.328}\ DBIVTD_{t-1} + \underset{(1.9)}{0.268}\ DBIVTD_{t-2} + \underset{(7.4)}{0.073}\ BOK_{t-1}$$

$R^2 = 0.9439$ $S = 15.9726$ $DW = 1.9038$

7. Neoclassical Model 5 -- with the ratio of net worth to market value as capital cost (without capital gains)

$$BIVTD_t = \underset{(2.7)}{72.834} - \underset{(-2.1)}{0.267}\ DBNE5_t + \underset{(2.0)}{0.458}\ DBIVTD_{t-1} + \underset{(9.6)}{0.074}\ BOK_{t-1}$$

$R^2 = 0.9318$ $S = 13.1133$ $DW = 2.1251$

8. Neoclassical Model 6 -- with the ratio of book value of networth to market value as capital cost (with capital gains)

$$BIVTD_t = \underset{(3.3)}{80.429} - \underset{(-2.6)}{0.252}\ DBNE6_t + \underset{(1.9)}{0.403}\ DBIVTD_{t-1} + \underset{(10.0)}{0.074}\ BOK_{t-1}$$

$R^2 = 0.9415$ $S = 12.1502$ $DW = 2.3975$

9. Neoclassical Model 7 -- with Bell long term bond yield as capital cost (without capital gains)

$$BIVTD_t = \underset{(3.2)}{80.481} - \underset{(-2.5)}{0.057}\ DBNE7_t + \underset{(2.0)}{0.438}\ DBIVTD_{t-1} + \underset{(9.6)}{0.071}\ BOK_{t-1}$$

$R^2 = 0.9403$ $S = 12.2748$ $DW = 2.1624$

10. Neoclassical Model 8 -- with Bell long-term bond yield as capital cost (with capital gains)

$$BIVTD_t = \underset{(3.9)}{94.184} - \underset{(-2.8)}{0.007}\ DBNE8_t + \underset{(1.4)}{0.279}\ DBIVTD_{t-1} + \underset{(10.0)}{0.071}\ BOK_{t-1}$$

$R^2 = 0.9467$ $S = 11.5921$ $DW = 2.3649$

Table IV

Capital Expenditures on New Equipment and Construction by

Bell Canada

1. Accelerator Model

$$BIVTD_t = \underset{(2.4)}{51.713} + \underset{(3.7)}{2.386}\ DBREVD_{t-1} + \underset{(3.0)}{0.585}\ DBIVTD_{t-2} + \underset{(1.5)}{0.023}\ BOK_{t-1}$$

$R^2 = 0.9554$ $S = 10.6073$ $DW = 2.6717$

2. Expected-profit Model

$$BIVTD_t = \underset{(5.3)}{98.115} - \underset{(-2.9)}{0.165}\ DBMKD_t + \underset{(2.4)}{0.513}\ DBIVTD_{t-2} + \underset{(7.7)}{0.065}\ BOK_{t-1}$$

$R^2 = 0.9418$ $S = 12.1198$ $DW = 2.0931$

3. Neoclassical model 1 -- with earning yield as cost of capital (without capital gains)

$$BIVTD_t = \underset{(2.6)}{69.512} - \underset{(-2.0)}{0.031}\ DBNE1_{t-1} + \underset{(1.7)}{0.412}\ DBIVTD_{t-1} + \underset{(8.1)}{0.080}\ BOK_{t-1}$$

$R^2 = 0.9269$ $S = 17.3880$ $DW = 1.6261$

4. Neoclassical Model 2 -- with earning yield as cost of capital (with capital gains)

$$BIVTD_t = \underset{(2.3)}{61.201} - \underset{(-1.8)}{0.005}\ DBNE2_t + \underset{(1.6)}{0.388}\ DBIVTD_{t-1} + \underset{(8.3)}{0.082}\ BOK_{t-1}$$

$R^2 = 0.9221$ $S = 17.9443$ $DW = 1.4634$

5. Neoclassical model 3 -- with profit rate as cost of capital (without capital gains)

$$BIVTD_t = \underset{(3.3)}{75.215} - \underset{(-3.1)}{0.045}\ DBNE3_t + \underset{(2.1)}{0.436}\ DBIVTD_{t-1} + \underset{(8.9)}{0.076}\ BOK_{t-1}$$

$R^2 = 0.9460$ $S = 14.9435$ $DW = 1.8484$

From the above results we can compare the relative performance of various models in explaining the investment behaviour of this industry. One's judgement on this question will of course depend upon the purpose for which the model is constructed. Nevertheless, there are three criteria commonly adopted in empirical studies. From the viewpoint of pure prediction of investment expenditures, the best measure of relative performance is the standard error of the estimate of the best distributed-lag function corresponding to each model. The model which yields the least sum of squared residuals from the best regression equation will give the best explanation of investment behaviour of this industry and make the smallest prediction error in the long-run. To make the residual variances of different models comparable we must correct them for the degrees of freedom. Thus again the standard error of regression is chosen as a major statistic for comparison of the various models.[1]

A second criterion to judge the relative performance of the various models is the economic plausibility of these models. While it is possible to find a series of numbers which, used to approximate desired capital stock, could result in a small standard error, such an investment function may be completely meaningless economically. A simple indicator would be to assess the sign and magnitude of the estimated coefficients against *a priori* information that may be available to us. Unfortunately,

---

[1] Strictly speaking, to use the standard error of the estimate as a basic statistic for comparison of goodness of fit the disturbance term of the best distributed function must be serially uncorrelated. Otherwise the conventional formula for calculating standard errors can be seriously misleading. However, since the values of the Durbin-Watson statistics corresponding to various models do not, except in very few cases, suggest the presence of either positive or negative serial correlation, we may not be committing any serious error in assuming that the true disturbance u is random.

since information in the public domain about this industry is quite limited, we are unable to make any independent calculation of the magnitude of the coefficients. Nevertheless, the signs of the coefficients on both the change in the desired capital and the existing stock of capital may be easily specified on intuitive grounds. (Especially if coefficients associated with changes in the desired capital are negative, one may reasonably be suspicious of the results.)

A third way to evaluate the relative performance of various models is to analyze the variance of the estimated coefficients. The coefficients associated with changes in desired capital are again of particular interest. Without these terms, net investment would be determined completely by its past history; such an investment theory is hardly of any interest.

For convenience of comparison, Tables V and VI have been compiled from the results in Table I and IV. Column 3 of these tables contains the standard errors for the various models. Other relevant information recorded in the tables are R^2, Durbin-Watson statistic, total number of significant coefficients at 5% level of significance, number of significant coefficients of changes in the desired capital stock, and number of β coefficients with the wrong sign.

It is clear from these tables that, as far as the explanatory or predictive power is concerned, the accelerator model performs better than all other models except the NM-9. In most cases the accelerator model explains investment behaviour better for both the Canadian telephone industry and Bell Canada than other models, by more than 30% in terms of standard errors. Generally speaking, this model performs slightly better than the

expected-profit model which in turn is superior to most of the Jorgensonian neoclassical models. By comparison with the modified neoclassical models (NM-9 and NM-10), however, the accelerator model performs rather badly. This is hardly surprising since both NM-9 and NM-10 include as the principal explanatory variables not only the major determinants of the accelerator model -- change in the output -- but also the relative price of output to rental value of capital service.

Among the Jorgensonian models there is virtually no distinct advantage or disadvantage by including (our poor measure of) capital gains in the measure of rental value of capital service. Of the four different measures of rental two improve the standard errors slightly, by including capital gains, the other two actually are somewhat worse. As to the different measures of rental, evidence from both the industry and the Bell Canada data does suggest that the long-term bond yield explains investment expenditures better than the other three. This result corroborates the arguments of Modigliani and Miller [29].

Turning now to the second criterion for evaluating the relative performance of the various models,one observes from the last column of both tables that the superiority of the accelerator model over any others is overwhelming. It is surprising to point out that in almost all the neoclassical models and the expected-profit model the coefficient associated with changes in desired capital carries the wrong sign. In the cases where the β coefficients do retain a correct sign, they either are insignificant at the 5% level of significance or associated with changes in the output of the industry. The only exception is the model labelled NM-1 applied to the telephone industry data. If any of the models

showing an incorrect sign for all the β coefficients in fact carried the true specification of the investment function for telephone service, it would mean that (other things being equal) investment could increase as revenue decreases or rental increases, or both. In the short-run such a result might occur due to uncertainty or unpredictable changes in market conditions; it could hardly be plausible in the long-run.

With respect to the third measure of relative performance, we found that the accelerator model performs slightly better in some cases equally well in others. All except the model NM-9 have at most only one significant β coefficient. In seven out of the 24 cases none of the β coefficients in significant.

Table V

Comparison of Various Investment Models for the Canadian Telephone Industry

Regression #	Model	S	R^2	DW	Total no. of coefficients	No. of sig. coefficients	total no. of β's	no. of sig. β's	no. of β's with wrong sign
1	AM	17.1149	0.9705	3.0184	4	4	1	1	0
2	PM	21.0566	0.9603	2.2257	5	3	2	1	2
3	NM-1	21.8472	0.9519	1.9705	4	3	1	1	0
4	NM-2	31.4495	0.9002	1.5728	4	1	1	1	1
5	NM-3	31.3174	0.9121	2.1397	5	2	1	0	0
6	NM-4	30.0855	0.9087	2.2036	4	1	1	0	1
7	NM-5	30.6935	0.9155	2.2036	5	2	1	0	1
8	NM-6	30.5858	0.9161	2.3109	5	2	1	0	1
9	NM-7	29.0142	0.9245	2.2368	5	2	1	0	0
10	NM-8	29.8474	0.9301	2.3770	6	2	2	0	2
11	NM-9	14.9692	0.9904	2.6776	7	3	4	2	2
12	NM-10	17.3485	0.9730	2.8078	5	2	2	1	1

Table VI

Comparison of Various Investment Models for Bell Canada

Regression #	Model	S	R^2	DW	Total No. of coefficients	No. of sig. coefficients	Total no. of β's	No.of sign. β's	Number of β's with wrong sign
1	AM	10.6073	0.9554	2.6717	4	3	1	1	0
2	PM	12.1198	0.9418	2.0931	4	4	1	1	1
3	NM-1	17.3880	0.9269	1.6261	4	3	1	1	1
4	NM-2	17.9443	0.9221	1.4634	4	2	1	0	1
5	NM-3	14.9435	0.9460	1.8484	4	4	1	1	1
6	NM-4	15.9726	0.9439	1.9038	5	4	1	1	1
7	NM-5	13.1133	0.9318	2.1251	4	4	1	1	1
8	NM-6	12.1502	0.9415	2.3975	4	4	1	1	1
9	NM-7	12.2748	0.9403	2.1624	4	4	1	1	1
10	NM-8	11.5921	0.9467	2.3649	4	3	1	1	1

REFERENCES

1. Clopper Almon. The American Economy to 1975. New York: Harper and Row, 1966.

2. Charles W. Bischoff. "Elasticities of Substitution, CApital Malleability, and Distributed Lag Investment Functions", paper given at the San Francisco meeting of the Econometric Society, December 28, 1966.

3. Charles W. Bischoff, "Hypothesis Testing and the Demand for Capital Goods", The Review of Economics and Statistics,

4. H.B. Chenery, "Overcapacity and the Acceleration Principle", Econometrica, January 1952, XX 1-28.

5. Paul G. Clark, "The Telephone Industry: A Study in Private Investment", Studies in the Structure of the American Economy, edited by Wassily Leontieff, 1953.

6. J.S. Duesenberry, Business Cycles and Economic Growth, New York, 1958.

7. R. Eisner, "Capital Expenditures, Profits, and the Acceleration Principle", in Models of Income Determination, NBER study in Income and Wealth, No. 28, Princeton ,1964 pp. 137-76.

8. R. Eisner, "A Distributed Lag Investment Function", Econometrica XXVIII, January 1960, 1-29.

9. R. Eisner, "A Permanent Income Theory for Investment", American Economic Review, June 1967, 57, 363-90/

10. R. Eisner, and Nadiri, M.I. "Investment Behaviour and the Neoclassical Theory" Review of Economics and Statistics 50 (Aug. 1968), 369-382.

11. R. Eisner and R.H. Strotz, "Determinants of Business Investment", in Impacts of Monetary Policies, Commission on Money and Credit, Research Monograph (Prentice-Hall), 1963.

12. M.S. Feldstein and D.K. Foot, "The Other Half of Gross Investment: Replacement and Modernization Expenditures", Discussion Paper no. 105, January 1970, Harvard Institute of Economic Research.

13. Z. Griliches, "Capital Stock in Investment Functions: Some Problems of Concept and Measurement", Chapter 5 in Christ, (editor) Measurement in Economics, 1963.

14. Z. Griliches and N. Wallace, "The Determinants of Investment Revisited", International Economic Review, September 1965, 6, 311-329.

15. Y. Grunfeld, "The Determinants of Corporate Investment", in A.C. Harberger (editor), The Demand for Durable Goods, Chicago, 1960, pp. 211-66.

16. R.E. Hall and D.W. Jorgenson, "The Policy of Investment Behavior" American Economic Review, June 1967, 57, 391-414.

17. B.G. Hickman, Investment Demand and U.S. Economic Growth, Washington, 1965.

18. D.W. Jorgenson, "Capital Theory and Investment Behavior",American Economic Review, Proceedings, May 1963, 53, 247-59.

19. D.W. Jorgenson, "Anticipations and Investment Behavior", in J.S. Duesenberry, E. Kuh, G. Fromm and L.R. Klein, editors, The Brookings Quarterly Econometric Model of the United States, Chicago, 1965, pp. 35-92.

20. D.W. Jorgenson, "Rational Distributed Lag Functions", Econometrica January 1966, 43, 135-49.

21. D.W. Jorgenson and C.D. Seibert, "A Comparison of Alternative Theories of Corporate Investment Behavior", American Economic Review, September 1968, 681-712.

22. D.W. Jorgenson and J.A. Stephenson, "Investment Behavior in U.S. Manufacturing, 1947-60", Econometrica, April 1967, 35, 169-220.

23. D.W. Jorgenson and J.A. Stephenson, "The Time Structure of Investment Behavior in U.S. Manufacturing, 1947-60", Review of Economics and Statistics, Feb. 1967, 49, 16-27.

24. D.W. Jorgenson and J.A. Stephenson, "Issues in the Development of the Neoclassical Theory of Investment Behavior", The Review of Economics and Statistics, August 1969, 51, 346-353.

25. N. Kaldor, "A Model of Economic Growth", Economic Journal , Dec. 1957.

26. L.M. Koyck, Distributed Lags and Investment Analysis, Amsterdam, 1954.

27. J.R. Meyer and R.R. Glauber, Investment Decisions, Economic Forecasting and Public Policy, Boston, 1964.

28. J.R. Meyer,and E. Kuh, The Investment Decision, Cambridge, Massachusetts, 1957.

29. Modigliani and Miller, "The Cost of Capital, Corporation Finance, and the Theory of Investment", American Economic Review June 1958, 48, 261-97.

VI. Broadcast

1. Introduction

The broadcast sector of the telecommunications industry is different from the telephone and telegraph sectors in two significant respects. The first is that commercial broadcasting is a one-way medium. The audience listens or watches, but does not reply (except possibly by mail). The second is that the recipients of broadcasting are not the customers: the audience consumes, but the advertisers pay. The broadcast industry provides the facilities permitting advertisers to communicate with the audience. The size and composition of the audience are important to the industry since the advertiser bases decisions on the cost of reaching a potential purchaser of his product. The larger the audience, the greater will be the demand for advertising time. The members of the industry compete with one another and with other media for the attention of the audience and for the advertising expenditures of business.

Since the end of World War II, there have been dramatic changes in the broadcast industry. Radio used to play the role in home entertainment that television now does. Those over thirty can remember the family gathering around the radio many evenings to listen to favourite programs. In the late 1940's when American TV signals became available along the border, and especially in the early 1950's when domestic TV broadcasting began, radio broadcasting lost this audience and began to change the nature of its service. Radio now services an audience which by and large is busy doing something in addition to listening: rising and dressing in the morning, driving to and from work, cooking or cleaning, making a pretense of doing homework, or lying on the beach enjoying the sun. Radios seem to be everywhere but underwater. Despite the fact that radio has lost much of its share of national advertising to television, radio now has more

listeners and more advertising revenue than ever. National advertising constituted 39.6% of private radio advertising in 1968 while it was 75.8% of private TV advertising.

TABLE I

COMPOSITION OF ADVERTISING REVENUES, CANADA
1968

	National Advertising Revenue (millions)	Local Advertising Revenue (millions)	Total Advertising Revenue (millions)
Private Radio	36.9	56.5	93.4
Private TV	67.2	21.4	88.6

In order to meet the needs of the more specialized local markets there has been a rapid growth in the number of radio stations, although many of the new stations are FM subsidiaries of existing AM stations. From 1962 to 1968 the number of private radio stations increased from 198 to 319 while the number of private TV stations increased from 58 to 68.[1] The slower growth in the number of TV stations is a result of the limited availability of VHF spectrum in the large markets and a lack of sufficient revenue in small markets (UHF for smaller cities). Since it is much less expensive to operate, a radio station will be profitable if it can attract even a small audience with the socio-economic characteristics desired by an advertiser. Such "narrowcasting" seems likely to become even more widespread over the coming years.

In the post-war period, television in Canada has grown from nothing to an industry with two national networks and a number of independent stations. At the beginning there were only a few hours per day of black and white programming, but now colour programming is the rule for most of the 15 to 20-hour

---

[1] In addition to these private stations, at the end of 1969 the CBC operated 40 radio stations and 18 TV stations.

broadcasting day. The availability of the microwave networks of CN-CP and TCTS has made possible nationwide live broadcasting of events as different (similar?) as political conventions and football games complete with slow-motion instant replays of the more spectacular maneuvers.

Our goals in this chapter are to learn how advertisers make their decisions on expenditures, how these get translated into revenues of the broadcasting industry, and then how the industry decides how much labour and capital to use to satisfy this demand. Unfortunately, however, we will fall short of these goals, primarily because we lack sufficient data to carry out the required statistical analysis. We have been able to relate advertising revenues to the level of activity in the economy and to relate wages and salaries to revenue, but for a number of other data series we have been able to do nothing more than estimate exponential growth rates in order to outline the patterns of growth.

Data

The Dominion Bureau of Statistics began publishing occasional issues of Radio and TV Broadcasting Statistics (catalogue nos. 56-501,2,3) in 1956. In 1961 they published the first regular issue of Radio and Television Broadcasting (catalogue nos. 56-204) and in 1962 there was a major reclassification of the data. The major categories in the 1962 issue are:

a) The Industry (Radio plus TV, with CBC and private)

b) Private Radio

c) Private TV

CBC is not split into radio and TV, presumably because the plant and labour force are used in common. Revenue by source and various expenses are published for each category. For the industry, it is possible to extend

most of the series back to 1956, but for private radio and TV only a sample of seven observations from 1962 to 1968 is available. For these short series we have calculated only the annual percentage growth rates since it would be hazardous to estimate causal relations from regressions using so few data. For the longer series, we have fitted dynamic demand equations for advertising revenues and static equations for wages and employment.

3. Results

a) Revenue

For the industry we have used the Houthakker-Taylor model to estimate demand measured by total advertising revenue and its two components, local advertising and national advertising. Our reasons for using the Houthakker-Taylor model are somewhat unusual because in the case of broadcasting both the audience and the advertisers are habituated to television. Audience habit formation takes two forms: loyalty to specific programs or stations and stability in viewing or listening hours. Even though the audience does not pay for the service, its habits are relevant to estimation of revenue of the broadcasters, since advertisers base decisions on cost per thousand viewers (CPM). A station which captures a larger audience raises its rates (and revenue) while CPM remains at about the same level. The habituation of advertisers is perhaps less obvious, but loyalty to other media may exist in the form of long term contracts. In addition, adjustment to new marketing opportunities takes time, and this is captured in the dynamic framework of the Houthakker-Taylor model.

We first tried to explain the share of broadcasting revenue in terms of total advertising expenditure for all media and also in terms of total advertising agency billings for all media. However, there were insufficient observations to be able to use total advertising expenditure. When we

used agency billings to explain broadcast revenue, we found a satisfactory fit, but better results were obtained using GNP directly. This somewhat surprising result may reflect different contractual arrangements in broadcasting as opposed to publications . In broadcasting the advertiser frequently purchases a program for a whole season or year, and this decision is probably based on some measure of prosperity. On the supply side, a broadcaster has to fill the air for most or all of the day, while magazines and newspapers can publish fewer pages to cut costs. However, publishing feels the effects of the business cycle more than broadcasting. In Tables II and III, reproduced from DBS Advertising Expenditures in Canada (Catalogue No. 63-216), we have the breakdown of advertising expenditures and agency billings into their components. It should be noted, however, that in Table III the importance of TV is overstated since most TV advertisements are placed through agencies, while much newspaper and radio advertising is placed directly.

TABLE II

Estimated Advertising Expenditures in Canada, 1964, 1966 and 1967

Component -- Élément	1964	1966	1967	1967/1966 change -- Variation
	dollars			%
All components - Total - Ensemble des éléments	739,406,742	898,400,579	967,603,701	7.7
Printed advertising -- Publicité imprimée	438,535,473	518,792,000	550,521,000	6.1
Radio -- Publicité radiophonique	65,120,940	80,047,487	88,457,839	10.5
Television -- Publicité télévisée	80,662,036	100,391,057	111,252,950	10.8
Advertising agencies' commissions -- Commissions des agences de publicité	46,596,607	57,082,209	63,118,282	10.6
Outdoor advertising -- Publicité extérieure	46,674,758	73,975,379	84,494,008	14.2
Direct mail (postage only) -- Publicité directe (frais de poste seulement)	35,336,250	34,964,025	35,319,450	1.0
Miscellaneous -- Publicité diverse	26,480,678	33,148,422	34,440,172	3.9

TABLE III

Percentage Distribution of Commissionable Billings by Medium and Agency Commissions, 1956-1967

Year -- Année	Total commissionable billings -- Publicité à la commission, valeur totale	Percentage distribution of commissionable billings -- Répartition proportionnelle de la publicité à la commission						Agency commissions -- Commissions des agences
		Publications	Other visual -- Autres moyens visuels	Production, artwork, printing, etc. -- Production, dessin publicitaire, impression, etc.	Radio	Television -- Télévision	Other -- Autres	
	dollars	per cent -- pourcentage						dollars
56	201,797,434	52.6	4.4	15.3	10.3	16.6	0.8	30,452,807
57	222,025,288	51.6	4.4	15.1	10.0	18.3	0.6	33,377,463
58	233,789,205	49.3	4.7	14.4	10.5	20.5	0.6	35,277,406
59	250,080,021	47.8	4.8	14.7	10.6	21.3	0.8	37,678,828
60	267,756,156	47.2	5.1	18.7	9.7	19.3	--	39,993,639
61	277,805,963	45.5	4.6	19.0	9.4	21.4	0.1	41,253,508
62	293,028,021	44.0	5.1	17.2	10.8	22.8	0.1	43,496,564
63	296,762,297	42.2	4.6	16.2	10.7	26.3	--	44,270,021
64	311,332,070	40.4	3.9	18.4	10.5	26.7	0.1	46,596,607
65	354,650,007	39.5	3.7	18.9	10.4	27.4	0.1	52,883,006
66	392,542,021	38.8	3.4	19.5	10.5	27.8	--	57,082,209
67	420,092,360	37.2	3.5	18.5	11.3	29.1	0.4	63,118,282

Amount too small to be expressed. -- Montant infime.

It would be desirable to deflate total broadcast advertising revenue to a constant-dollar measure of output, but there are no obvious price indices to use. While it might be possible to collect per-minute advertising rates for a sample of radio and TV stations, even this information would not be sufficient. The problem is that rates depend on audience size, which means that there would be a major difficulty in separating price changes from changes in audience. Moreover, quantity discounts for clients with large advertising expenditures further complicate matters since changes in the proportion of revenue billed at full rate should affect the index. While it is standard practice to give these discounts, we were unable to find any information as to

their effect on industry revenue. Consequently, in the equations that follow we have used current dollar advertising revenue and current dollar GNP.

State Adjustment Models [$A_3 = A_2$. For description of Houthakker-Taylor model see Chapter III].

(1) $q_t = -15.82 + .5386\, q_{t-1} + .00176\, X_t$ $\qquad R^2 = .993$
$\qquad\quad (-1.4) \qquad (1.8)$ $\qquad DW = 1.44$

(2) $q_{1t} = -4.09 + .8402\, q_{1t-1} + .00033\, X_t$ $\qquad R^2 = .994$
$\qquad\quad (-.7) \qquad (1.9)$ $\qquad DW = 1.85$

(3) $q_{nt} = -11.58 + .3799\, q_{nt-1} + .00140\, X_t$ $\qquad R^2 = .990$
$\qquad\quad (-1.6) \qquad (1.5)$ $\qquad DW = 1.65$

q_t = total advertising revenue of broadcast industry (millions)

q_{1t}= local-advertising revenue of broadcast industry (millions)

q_{nt} = national-advertising revenue of broadcast industry (millions)

X_t = GNP in current dollars (millions).

These results are quite good except for the GNP coefficient in the local-advertising equation which has an unsatisfactory t-radio. Despite this, however, the income elasticities computed from the equation are reasonable, as are the elasticities from the other two equations (see Table IV).

The coefficients in the basic model indicate that habit formation is present and is stronger in local advertising than in national advertising. We think that this result stems from both audience and advertiser habituation. Since most local advertising is in radio, this result indicates greater audience loyalty to radio programs or stations than to TV programs or stations. Vitually all national advertising is placed through advertising agencies, while much local advertising is placed directly. The agencies appear to be less

subject to habit formation than businessmen who place ads directly.

The income elasticities computed in table IV show that advertising revenue grows faster than GNP and that local advertising is growing faster than national advertising, although national advertising responds more quickly to changes in GNP as a result of weaker habit formation.

TABLE IV

Income Elasticities

Equation	S.R.	L.R.
(1)	.4016	1.3390
(2)	.1642	1.8905
(3)	.5761	1.2822

From published data it is possible to separate CBC and private advertising revenue only for the period 1962 to 1968. Therefore we did not try to estimate revenue as a function of GNP, but we did compute growth rates for the period and these are given below in Table V.

TABLE V

Annual Percentage Rates of Growth and 1968 Levels

	Growth Rate	1968 Level
CBC local advertising revenue	-6.4 % p.a.	1.3 million $
CBC national advertising revenue	4.4	26.6
CBC total advertising revenue[1]	3.7	27.9
CBC total revenue including grants	10.4	175.5
Private total advertising revenue (radio & TV)	11.5	182.0
Private radio local advertising revenue	10.9	56.5
Private radio national advertising revenue	8.9	36.9
Private radio total advertising and other revenue	9.9	95.7
Private TV local advertising revenue	10.0	21.4
Private TV national advertising revenue	14.2	67.2
Private TV total advertising and other revenue	13.1	100.0

[1] The figure for 1968 CBC advertising revenue is for net revenue. The public accounts give a figure of 38.7 million which is gross revenue. The difference is about evenly divided between advertising agency commissions and remission of revenue to private stations carrying CBC programs with national advertising. Of CTV network national advertising revenue, 75% is distributed among the member stations and 25% is retained by the network. The latter is not included in the DBS figures.

Table V shows that CBC advertising revenues have not grown as much as private revenue, in part because the number of private radio and TV stations has increased much faster than the number of CBC stations. However, total revenues of the public and private sectors have grown at similar rates.

A comparison of the growth rates of revenue in the private radio and private TV areas reveals four important trends. First, we see that all the growth rates are high when compared to GNP or most other major sectors of the economy. Second, TV revenue is growing faster than radio by about 3% per annum. This is probably in part due to more rapid increases in TV advertising rates than in radio rates. In addition, TV stations may have sold more of their available time in the latter part of the period. The third and fourth trends are that in radio local advertising grows more rapidly than national advertising, while in TV national advertising grows more rapidly than local.

We have not attempted to explain CBC grants. These grants make up a very important part of industry revenue. For most of the period the grant has been about the same size as total radio and TV national advertising has been appreciably higher in 1967 and 1968. In 1968 local advertising revenue was 79.2 million dollars, national advertising 130.8, the grant was 145.6 and non-advertising industry revenue was 15.6 million dollars. Of the total advertising revenue of 210.0 million, 182.0 million was private and 28.0 million was CBC revenue.

b) Expenses and Employment

Since for the CBC profits are zero, the grant amounts to a subsidy equal to the amount by which revenue falls short of expenses (excluding depreciation and amortization). In the private sector, profits after taxes have

increased from 1.75 millions dollars in 1962 to 17.1 million dollars in 1968. From 1964 to 1968 net operating revenue has been close to 15% of total private revenue.

Wages and salaries are the largest item in the list of expenses, comprising about 40% of total expense for both the private and public sectors of the industry. For the whole industry for the period 1956-68 we estimated the relation between wages and revenue (including non-advertising revenue and grants). The equation follows:

$$(4.)\quad \text{Wages} = \underset{(1.7)}{3.24} + \underset{(46.0)}{.3758}\ \text{Revenue} \qquad R^2 = .995 \quad DW = .84$$

This equation is quite good for a static model, but it has high positive autocorrelation as indicated by the low Durbin-Watson statistic.

We attempted to explain employment in terms of revenue, but could not find a satisfactory equation. We also tried linear and semi-log regressions of the number of employees against time. The best fit was with the linear equation, which estimated that employment in the industry increases by 685 workers per year.[2]

In Tables VI and VII we separate the industry into CBC and private components and then further separate the private component into radio and TV. From Table VI we see that the public and private sectors have been growing at roughly comparable rates.

---

[2]The equation:

$$\text{No. of employees} = \underset{(43.0)}{10552} + \underset{(22.0)}{.685}\ [\text{Year} - 1955] \qquad R^2 = .978 \quad DW = 1.31$$

TABLE VI

Annual percentage rate of growth, 1962-68 and 1968 levels

	Rates of growth, % p.a.			1968 levels, millions, except employees		
	Industry	Private	CBC	Total	Private	CBC
Total Expenses	10.0	9.6	10.4	341.2	165.8	175.5
Wages and Salaries	10.0	8.9	11.1	145.4	67.0	78.4
Employees	3.3	3.4	3.3	19,232	10,067	9,165
Depreciation	11.0	9.2	13.6	19.8	11.3	8.4

TABLE VII

Percentage rates of growth and 1968 levels

	Growth Rates		1968 levels (million $ except employees)	
	Priv. radio	Priv. TV	Priv. radio	Priv. TV
Total expenses	8.8	10.4	83.3	82.5
Wages & Salaries	9.2	8.4	39.6	27.4
Employees	4.5	2.7	6134	3933
Staff Benefits	16.6	17.9	1.7	1.5
Artist & other talent fees	2.5	7.8	2.4	3.6
Performing rights	10.7	15.2	2.1	1.8
Films, tapes and recordings, rental and purchase	9.5	17.8	.8	16.2
Telephone, telegraph, microwave and outside services	12.3	12.0	8.5	4.0

As expected, the faster growth in private TV revenue is repeated in expenses. However, for both radio and TV, expenses have not grown as rapidly as revenues, which means that profits have increased more rapidly than revenues. Profit per dollar of revenue has also increased rapidly. For TV we see that artist and talent fees, performing rights and films, tapes, and recordings have been growing faster than for radio. Not only have they grown at faster rates, but film and tape rentals are also an important part of total TV expenses.

c) Capital

DBS publishes data referring to gross and net fixed assets of the industry, in this case split into radio and TV categories but not into private and public (CBC) segments. Thus only the total capital series is comparable with the series for industry total revenue and expenses (see Table VIII).

TABLE VIII

Percentage growth rates and 1968 levels

	Growth Rates			1968 Levels		
	Industry	Radio	TV	Industry	Radio	TV
Gross fixed assets	12.2	11.4	12.6	321.2	107.3	213.9
Accumulated Depreciation	12.1	9.1	13.8	143.1	46.4	96.8
Net value of fixed assets	12.2	13.5	11.7	178.1	60.9	117.2
Book value of technical and studio equipment	13.4	10.3	14.9	202.8	56.7	146.1

The more rapid growth in fixed assets, depreciation, and equipment for TV presumably reflects the heavy expenses associated with the introduction of colour television. This is reflected in the higher rate of growth of depreciation due to accelerated depreciation. Note that the faster growth of fixed assets in TV has occurred in spite of the fact that the number of radio stations has been increasing more rapidly than the number of TV stations.

It is possible to get a rough idea of the trends in gross investment by subtracting 1962 assets from 1968 assets. Unfortunately, however, this yields an underestimate of the rate of investment since it ignores the scrapping of obsolete equipment.[1] In Table IX we present the percentage increase in these assets over the six-year period and the average annual level of indicated gross investment in the period. The largest increases in the period occurred in 1966 where the change in assets exceeded the average by nearly 100%.

TABLE IX

Percentage increase in gross assets and average annual investment.

1962-68

	Percentage increase			Average annual investment		
	Industry	Radio	TV	Industry	Radio	TV
Total fixed assets	98.8	101.3	97.7	26.6	9.0	17.6
Technical & studio equipment	111.3	76.1	129.0	17.8	4.1	13.7

[1] Compared with the data supplied directly by the Division of BUsiness and Finance of DBS, the average annual level of gross investment is somewhat (about 7.7%) lower than the figure in Table IX. See Table XV of Chapter II.

Again we see the higher rate of investment in technical and studio equipment of TV as a result of the purchases of colour equipment. In fact, for TV, almost 80% of the 17.6 million dollars total average investment is spent on equipment. For radio, equipment is about 45% of total investment.

We have to do some aggregation in order to compute capital/output ratios, since DBS presents revenue split into public and private, but presents capital stock data split into radio and TV. In Table X we use total radio plus TV capital and public plus private revenue. Revenue is advertising revenue plus non-advertising revenue plus the CBC grant. The incremental capital/output ratio was computed using the total change in assets and revenue from 1962 to 1968.

TABLE X

Broadcast Industry Capital/Output ratios and their rates of change.

	Growth Rate 1962-1968	1968 - Capital / Output Ratio	Incremental Capital - Output Ratio
Gross capital	1.0%	1.154	1.257
Net capital	1.6%	.644	.714
Gross technical & studio equipment	1.7%	.699	.773

The capital/output ratios in Table X are much lower than those in telephone and telegraph industries. In part this is to be expected since in broadcasting the audience supplies a large part of the capital used to provide the service. While the telephone company supplies the telephone and the local

loops for its customers, the TV viewer provides the receiver and antenna himself.[3] Capital/output ratios have been rising as is shown by the growth rates in Table X

. Conclusions

A scarcity of data has limited the analysis we have been able to undertake for the broadcasting industry. What data there are show that broadcasting is a rapidly growing industry, and that there are important differences between broadcasting and other sectors of telecommunications. We have seen that radio and TV differ in the makeup of their advertising revenue and in the mix of capital and other inputs. Perhaps the most interesting finding is that advertising expenditures for radio and TV time respond more quickly to changes in income at the national level than at the local level. Whether this reflects a greater control of expenditures at the national level or just inertia in local expenditures, however, must for now be left a matter of conjecture.

---

3 Or he may subscribe to a cable TV (CATV) service. In 1968 there were 377 CATV stations, an increase of 63 from 1967.

	Subscribers	Potential subscribers along existing wire-line facilities	Revenue
1967	408,853	1,225,410	22,114,690
1968	555,275	1,606,552	31,285,513

Unfortunately, we can say little more about CATV since 1967 and 1968 are the only years for which DBS has published Community Antenna Television (catalogue no. 56-205). CATV is a very rapidly growing sector of the telecommunications industry and has potential use as a two-way communications system which may be of great importance in data communications in the future. Within the context of a statistical background paper we cannot pursue this issue.

VII. MANUFACTURING

1. Introduction

The suppliers of capital goods to the telecommunications sector are included by the Dominion Bureau of Statistics in two separate industries -- communications-equipment manufacturers and manufacturers of electric wire and cable. Both of these industries include suppliers and products which are not used by the telecommunications sector. For example, the products sold by the communications-equipment industry include telephone materials, domestic radio-receiving sets and record players, radio communication equipment for national defence, sonar equipment, and public address systems. Table 1 shows that in 1967, 46% of the products manufactured by electric wire and cable suppliers was of the type used by telecommunications companies, while 35% of the goods produced by the communications-equipment industry flowed to telecommunications companies. Although telecommunications carriers are major purchasers of the products of these two industries, other purchasers account for over 60% of their combined output. In the analyses which follow, however, we rely mainly on aggregate data for the manufacturers rather than on the products specific to telecommunications since most of the series needed are not segregated, and generally cannot be separated, according to the type of output.

2. Input-Output Tables

The 1961 Input-Output Table for Canada gives detailed information on the input mix for both communications equipment and electric wire and cable. An analysis of these tables is presented below in order to describe and compare the two industries.

One of the ways in which an input-output table describes the input mix of an industry is by estimating the effect on suppliers generated by an additional dollar of final demand for the industry's output.1/ These generated demands on suppliers include the direct effects of the increase in industry final demand and the indirect effects which the increase in demand for each supplier has on all other suppliers.

These direct and indirect derived demands are shown for both industries in Table 2 - The Impact Table. An increase, for example, of one dollar in final demand for communications equipment generates $.059 of business for base metal mines, taking into account the demand for base metal mines output directly generated by communications equipment manufacturers and the effects of the increased demand which metal stamping, iron and steel mills, aluminum rolling and casting, etc., have on base metal mines. An increase in one dollar of final demand for the wire and cable industry increases the economy's wage payments in wire and cable manufacture itself and indirectly through the increase in the wage bill for all the suppliers to wire and cable.

Other than primary inputs, the major suppliers affected by an increase in final demand for equipment are ferrous and non-ferrous metals ($.36), services ($.30), and manufacturing (.18 -- neglecting the impact on communications equipment and wire manufacturing). For wire

---

1/ Of course, the relevance for the industry in 1969 or 1980 depends on the constancy of the technological coefficients which underlie any input-output table. Our analyses assume that input coefficients can be taken to be constant. Work presently in progress at the Dominion Bureau of Statistics will ultimately permit some analysis and projection of observed trends in the technological coefficients of the input-output table, and therefore some testing of this assumption.

TABLE 1

Value of Shipments (Goods of Own Manufacture), Communications Equipment, Electric Wire and Cable Industries, 1960-67 (millions of current dollars)

	Shipments Wire and Cable Industry	% Wire and Cable[1/] Shipments to Telecom.	Shipments Comm. Equip.	% Comm. Equipment[2/] Ship. to Telecom.
1960	161	52	252	40
1961	163	49	251	40
1962	181	46	311	39
1963	195	49	361	39
1964	227	48	402	37
1965	274	51	431	37
1966	341	50	507	35
1967	318	46	619	36

1/ The electric wire and cable products sold to telecommunications companies are considered to consist of:

telephone cables -- exchange, toll and toll entrance
telephone wires insulated
telephone switchboard wires and cables
telephone cordage
bare wires and cables (it is unlikely that the telecommunications
power cable sector was the only purchaser of these products)

2/ The communications equipment sold by this industry considered to flow to telecommunications companies consist of:

telephone materials
carrier current equipment (values for 1963-65 assumed to be average of 1960-62, 1966)

Broadcast studio equipment should be included in the estimate of communications equipment sold to communications carriers and radio and T.V. broadcast companies. In 1960, domestic manufacturers shipped $6.1 million of studio broadcast equipment (or 2.4% of these manufacturers' total shipments) while in 1967, 1.8% of shipments of communications equipment consisted of broadcast studio equipment ($10.9 million).

Source: Wire and Cable: DBS, Manufacturers of Electric Wire and Cable, 1960-67.

Communications Equipment: DBS, Communications Equipment Manufacturers, 1960-67.

TABLE 2

Impact Coefficients ($) for a $1.00 Increase in Final Demand

	Communications Equipment		Wire and Cable	
	Imports Incl. (1)	No Imports (2)	Imports Inc. (3)	No Imports (4)
Base Metal Mines	.059	.038	.064	.042
Printing-Publishing	.017	.013	.017	.013
Iron & Steel Mills	.031	.020	.028	.018
Smelting & Refining	.143	.105	.154	.115
Alum. Roll. Cast.	.039	.029	.049	.039
Copper Roll. Cast.	.086	.077	.091	.082
Metal Stamping	.022	.016	.018	.013
Comm. Eq. & Wire Mfg.	1.027	.990	1.099	1.062
Elec. Indust. Eq.	.044	.034	.028	.019
Other Elec. Prod. Ind.	.057	.052	.009	.008
Plastic Resin Mfg.	.024	.013	.024	.013
Other Chem. Ind.	.032	.015	.032	.015
Misc. Mfg. Ind.	.027	.021	.016	.010
Construction	.017	.014	.017	.014
Wholesale and Retail Trade	.055	.045	.053	.045
Transportation and Storage	.044	.035	.043	.034
Communications	.019	.016	.018	.015
Utilities	.024	.018	.024	.018
Fin. Insur. Rl. Est.	.049	.042	.049	.042
Other Services	.016	.012	.016	.012
Advertising and Travel	.033	.028	.031	.026
Operating Suppl.	.058	.048	.058	.048
Indir. Tx. & Gov. Ser.	.026	.021	.026	.021
Wages and Salaries	.657	.570	.657	.571
Net Inc. Unincorp.	.023	.018	.023	.018
Surplus	.288	.232	.289	.233
Import Coefficient		.334		.058

Source: DBS Catalogue No. 15-502 (1961), Vol. 2, Table 15 -- Impact Table Without Import Leakages and Table 16 -- Impact Table With Import Leakages.

TABLE 3

Impact of $1.00 Increase in Final Demand

	Communications Equipment		Wire and Cable	
	No Imports	Imports Incl.	No Imports	Imports Incl.
Wages & Salaries	$.66	$.57	$.66	$.57
Surplus and net income unincorporated business	$.31	$.25	$.31	$.25
Indirect Taxes	$.03	$.02	$.03	$.02
Metals	$.36	$.29	$.40	$.31
Manufacturing	$.18	$.14	$.10	$.05
Services	$.30	$.22	$.30	$.23

and cable producers, an additional dollar of final demand generates direct and indirect demands of \$.40 worth of ferrous products, \$.19 of service inputs and \$.10 of manufactured materials. Each industry generates \$.99 of demand (direct and indirect) for primary inputs (labour, surplus, and indirect taxes).

The Canadian economy is not a closed one. Therefore, the above measures of the demand generated by an increase in the final demand for equipment and wire and cable which neglect the direct imports of equipment for final demand and the indirect imports of supplies used in the manufacturing of equipment and cable overestimate its true impact on domestic suppliers. Columns (2) and (4) of Table 2 give the impact coefficients including import leakages for communications equipment and wire and cable, respectively. For equipment manufacture, \$.33 of each dollar spent on final demand goes directly to foreign suppliers, while \$.06 of each dollar of final demand for wire and cable products goes directly to foreign producers. Including direct and indirect import leakages reduces the income flows to wage earners from \$.66 to \$.57 for both industries. Table 3 gives summary statistics on the impact coefficients for both industries, with and without import leakages. As can be seen from that table, wire and cable manufacture uses relatively more metals inputs and less manufactured inputs than does communications equipment production. A substantial proportion of the direct and indirect non-primary inputs to both industries is imported. For example, nearly 20% of the services used in production for these industries is imported.

While input-output analysis gives us great detail on the operations of the industries in one year, input-output analysis cannot describe the changes which occur over time in any one industry. We now turn to a brief description of the trends in communications equipment and wire and cable manufacturing.

3. General Trends

As can be seen from Tables 4 and 5, the two industries exhibited different growth patterns over the period 1957-1968. Shipments of communications equipment increased 246% over the period while wire and cable shipments doubled. The total number of employees increased by only 11% in the wire and cable industry but by 90% in communications-equipment production. Average labour productivity trends, however, do not show such a wide divergence between the two industries. Between 1957 and 1968, the value of shipments per employee increased 82% in equipment manufacturing and 70% in wire and cable. For the period 1961 through 1968, shipments per production worker rose by 50% in wire and cable and by 45% in equipment production. Although the shipments of the communications equipment industry grew twice as fast as the wire and cable industry, equipment's demand for labour also grew faster than the labour requirements in the wire and cable industry, with the result that the change in labour productivity was similar for both industries.

These two tables suggest different production techniques for the two industries. While total wages and materials account in 1968 for 17% and 64%, respectively, of the total value of shipments for wire and cable producers in that same year, total wages amount to 37% and

TABLE 4

Wire and Cable Industry

Year	Shipments (Own Mfg.) $M (Current$)	Value added Mfg. $M	materials ($M)	Production Workers No. (000)	Production Workers Hrs. (M)	Production Workers Wages ($M)	All Employees No. (000)	All Employees Wages ($M)	Value Added Total ($M)
1957	160.4	n.a.	94.6	n.a.	n.a.	n.a.	7.5	31.4	n.a.
1958	141.2	n.a.	85.8	n.a.	n.a.	n.a.	6.8	30.2	n.a.
1959	161.5	n.a.	99.3	n.a.	n.a.	n.a.	7.0	32.7	n.a.
1960	160.7	n.a.	95.0	n.a.	n.a.	n.a.	6.7	31.9	n.a.
1961	163.3	63.0	103.3	4.4	9.7	19.9	6.5	31.5	64.2
1962	181.0	65.3	115.3	4.7	10.3	22.1	6.8	34.7	66.1
1963	195.4	66.9	127.6	4.7	10.6	23.3	6.8	36.0	68.1
1964	227.2	79.2	146.5	5.1	11.4	25.5	7.2	38.6	81.2
1965	274.7	95.1	182.5	5.6	12.3	30.0	7.9	44.0	97.6
1966	341.3	117.1	233.4	6.4	14.3	35.7	9.1	53.4	121.3
1967	317.8	107.2	203.6	6.3	13.3	35.6	8.9	54.2	109.8
1968	323.5	110.3	206.9	5.8	12.4	37.1	8.3	56.0	112.2
% Change 1961-68	98%	69%	100%	32%	35%	86%	23%	78%	75%
% Change 1957-68	102%	n.a.	119%	n.a.	n.a.	n.a.	11%	78%	n.a.

TABLE 4 (cont.)

Wire and Cable Industry

Year	Shipments / No. Prodn. ($)	Shipments / No. Empl. ($)	P. Wages / No. Prodn. ($)	Wages / No. Empl. ($)	Materials / Shipment (%)	P. Wages / M.V.A. (%)	Wages / V.A. (%)	M.V.A. / No. Prodn. ($)	Value added / No. Empl. ($)
1957	n.a.	21,387	n.a.	4,187	60.0%	n.a.	n.a.	n.a.	n.a.
1958	n.a.	20,765	n.a.	4,441	60.8	n.a.	n.a.	n.a.	n.a.
1959	n.a.	23,071	n.a.	4,671	61.5	n.a.	n.a.	n.a.	n.a.
1960	n.a.	23,985	n.a.	4,761	59.1	n.a.	n.a.	n.a.	n.a.
1961	37,117	25,123	4,523	4,846	63.3	31.6%	49.1%	14,318	9,877
1962	38,511	26,617	4,702	5,103	63.7	33.8	52.5	13,874	9,721
1963	41,574	28,735	4,957	5,294	65.3	34.8	52.9	14,234	10,014
1964	44,549	31,556	5,000	5,676	64.5	32.2	47.5	15,529	11,278
1965	49,054	34,772	5,357	5,570	66.4	31.5	45.1	16,982	12.354
1966	53,329	37,505	5,578	5,868	68.4	30.5	44.0	18,296	13,330
1967	50,444	36,348	5,651	6,090	64.1	33.2	49.4	17,016	12,337
1968	55,776	38,976	6,397	6,747	64.0	33.6	50.0	19,017	13,518
% Change 1957-68	n.a.	70%	n.a.	61%				n.a.	n.a.
% Change 1961-68	50%	55%	41%	39%				33%	37%

No. prodn. = Number of production workers

No. Empl. = Number of employees

M.V.A. = Manufacturing value added

P. wages = Production wages

V.A. = value added

TABLE 5

Communications Equipment Industry

Year	Shipments (Own Mfg.) ($M)	Value added (Mfg) ($M)	Materials ($M)	Production Workers No. (,000)	Production Workers Hours (M)	Production Workers Wages ($M)	All Employees No. (000)	All Employees Wages ($M)	Value Added (Total) ($M)
1957	194.7	n.a.	67.9	n.a.	n.a.	n.a.	22.7	87.9	n.a.
1958	200.8	128.6	66.6	n.a.	n.a.	n.a.	21.7	89.1	n.a.
1959	208.4	141.7	69.9	n.a.	n.a.	n.a.	22.3	95.7	n.a.
1960	232.9	154.8	81.3	n.a.	n.a.	n.a.	23.0	102.2	n.a.
1961	251.1	162.4	98.8	15.0	40.0	57.5	24.0	108.9	169.6
1962	319.8	210.8	117.3	18.2	37.8	70.2	27.7	125.6	220.9
1963	361.0	214.8	136.3	18.6	38.9	75.0	28.7	133.6	223.8
1964	401.8	249.2	158.0	19.6	42.2	82.3	30.6	150.4	261.5
1965	430.5	275.7	174.2	21.7	46.0	94.8	33.5	172.3	295.3
1966	506.9	325.4	212.6	25.6	54.2	117.9	38.5	203.4	347.8
1967	618.8	342.3	274.0	26.9	55.6	127.0	40.5	222.2	358.3
1968	674.5	386.5	285.7	27.8	59.2	144.7	43.1	248.9	402.3
% Change 1961-68	169%	138%	205%	85%	48%	152%	80%	129%	137%
% Change 1957-68	246%	201%*	321%	n.a.	n.a.	n.a.	90%	183%	n.a.

* 1958-68

TABLE 5 (cont.)

Communications Equipment Industry

Year	Shipments / No. Prodn. ($)	Shipments / No. Empl. ($)	P. Wages / No. Prodn. ($)	Wages / No. Empl. ($)	Materials / Shipments (%)	P. Wages / M.V.A. (%)	Wages / V.A. (%)	M.V.A. / No. Prodn. ($)	V.A. / No. Empl. ($)
1957	n.a.	8,577	n.a.	3,872	34.9	n.a.	n.a.	n.a.	n.a.
1958	n.a.	9,253	n.a.	4,106	33.2	n.a.	69.3	n.a.	n.a.
1959	n.a.	9,435	n.a.	4,291	33.5	n.a.	67.5	n.a.	n.a.
1960	n.a.	10,126	n.a.	4,443	34.9	n.a.	66.0	n.a.	n.a.
1961	16,740	10,463	3,833	4,537	37.4	35.4	64.2	10,827	7,067
1962	17,571	11,545	3,857	4,534	36.7	33.3	56.9	11,582	7,975
1963	19,409	12,578	4,032	4,655	37.8	35.0	59.6	11,546	7,798
1964	20,500	13,131	4,199	4,915	39.3	33.0	57.5	12,714	8,546
1965	19,839	12,851	4,369	5,143	40.5	34.4	58.3	12,673	8,815
1966	23,359	13,167	4,605	5,283	41.9	36.2	58.5	12,710	9,034
1967	23,004	15,279	4,721	5,486	44.3	37.1	62.0	12,725	8,847
1968	24,263	15,650	5,205	5,774	42.4	37.4	61.9	13,903	9,334
% Change 1957-68	n.a.	82%	n.a.	49%				n.a.	n.a.
% Change 1961-68	45%	58%		27%				28%	32%

No. prodn. - Number of production workers

No. empl. = Number of employees

M.V.A. = Manufacturing value added

P. wages = Production wages

V.A. = value added

materials 42% of the value of shipments for communications equipment manufacturers.[2/] The production process in wire and cable manufacture uses relatively more materials and less labour than in equipment manufacture.[3/] The relative difference in the use of labour can be seen by the value of shipments per worker (1968) -- $39,000 in wire and cable as compared to $15,600 for communications equipment. The wire and cable industry appears also to be more capital intensive than the production of communications equipment since total wages are 50% of total value added in wire and cable production and 62% in communications equipment production.

Different Size Classes -- Trends in the Average Plant

Since 1961, DBS has published data for both industries for individual plants grouped into nine (9) different size classes, using four different bases for grouping -- value of shipments, number of employees, manufacturing value added and total value added. Tables 6 and 7 list the size classes and the number of plants (establishments)

2/ The two different industries use very different materials inputs. Classifying raw materials as all-aluminum, copper, iron and steel, lead, lacquer resins and rubber-semi manufactured products used, raw materials account for 18% of material requirements for communication equipment manufacturers and 88% for wire and cable producers.

It is interesting to note that the impact table (Table 1) shows a similar impact on direct and indirect wages of an increase in final demand for both industries, although the direct wage component of total production costs differs substantially. Two hypotheses can explain these facts. One, the wage component of production is different for the products sold as final demand and the products sold as intermediate goods. Second (and more likely), the wage component of the materials used is similar to that in communications equipment

3/ The division of employees between production workers and other types of employees is similar in both industries with the ratio of production to other employees being approximately 2:1.

TABLE 6

Number of establishments grouped according to Selling value of Factory Shipments: Communications Equipment Manufacturers, 1960-61*

Year	Value of Factory Shipments: under $10,000	$10,000-$24,999	$25,000-$49,999	$50,000-$99,999	$100,000-$199,999	$200,000-$499,999	$500,000 $999,999	$1,000,000 $4,999,999	$5,000,000 and over	totals
1960	3	10	6	14	15	33	21	19	10	131
1961	2	5	7	14	16	27	19	24	11	125
1962*	2	9	7	12	20	27	19	27	14	137
1963		5	8	13	16	28	21	29	17	137
1964		11	6	14	15	25	23	31	18	143
1965		8	8	9	18	30	17	40	18	148
1966	5	6	9	8	21	32	27	42	18	168
1967	4	6	9	10	22	35	23	48	21	178

*1962-67, grouped according to shipments of goods of own manufacture

TABLE 7

number of establishments grouped according to size of shipments, wire & cable

1960-61, grouped according to selling value of factory shipments
1962-67, grouped according to shipments of goods of own manufacture

Year	under $200,000	$200,000 $999,999	$1,000,000 $4,999,999	$5,000,000 and over	total
1960	4	6	10	8	28
1961	5		12	8	25
1962	4		10	10	24
1963	3		10	11	24
1964	3		11	11	25
1965	12			13	25
1966	12			15	27
1967	3		10	16	29

in each size class for communications equipment (Table 6) and wire and cable manufacturers (Table 7).

It was noted earlier that the value of shipments in the communications equipment industry grew by 246% between 1957 and 1968. Between 1957 and 1968, the number of plants in this industry grew from 129 to 178 or 38%. This change in the number of establishments, however, was very different for the small as compared to the large size classes. The number of establishments below $1,000,000 in sales grew from 102 to 109. The great change in the number of plants therefore occurred in the two largest size classes, increasing in the period 1960-1968 from 29 to 69 plants.4/

In the electric wire and cable industry there were 29 plants in 1967 as compared to 28 in 1960 and 24 in 1957. The number of plants in the two largest size classes, however, grew from 18 in 1960 to 26 in 1967.

In any industry the growth which we observe in aggregate data such as in Tables 1, 4 and 5 consists of a complex pattern of change both in number and in size of plants. Industries may grow through the expansion of existing plants or an increase in the number of plants or some combination of the two.5/ An ideal analysis would require data on individual plants, their birth, growth, and death. Unfortunately, however, such data was not available for this study and as a result, the conclusions

---

4/ These figures overstate the amount by which these size classes grew in real terms. Inflation would increase the value of shipments for any given plant, even if there was no increase in real output. Some of the movement, although an unknown amount, into these two size classes is therefore due to inflation.

5/ Besides entering an industry, plants also can exit. Industry growth is a sum of the individual plants entry, exit and growth.

we draw from our analyses must be accepted with more than the usual grain of salt. Accordingly, the inconsistencies and biases resulting from the use of grouped data rather than data for individual plants will be mentioned wherever they are thought to be important.

The two industries in which we are interested exhibit different growth patterns not only in aggregate series such as the value of shipments, but also in changes in relative size and numbers of plants. An analysis of these changes follows.

Communications-Equipment-Changes in Plant Scale

In Table 8, data relating to the largest size-class ($5 million in shipments and over) are presented for the period 1957-1968. Although this class increased its share of the total output of the industry from 69% in 1957 to 74% in 1967, the average plant (total shipments of the class/number of plants in the class) in this size-class experienced a decrease in its relative share of industry output (from 34% in 1957, to 18% in 1968). As noted in footnote 4, however, these figures overstate the amount by which their size-classes grew in real terms, since inflation would increase the value of shipments for any given plant, even if there was no increase in real output. Some of the movement, although an unknown amount, into these two size-classes is therefore due to inflation.

If all plants in the largest size-class are equal to the average size of that class, then one plant would provide over 8% of the total industry sales in 1957 (or $17,100,100) and only 4% (or $20,900,000) in 1967. The second largest size-class increased its share of the market from 12.6% in 1957 to 18.3% in 1967, with the average size of a plant in this category virtually doubling over the period, going from $1,153,000

TABLE 8

Plant Data: Communications-Equipment Manufacturers, Value of Shipment of own Manufacture

	1957	1960	1961	1962	1963	1964	1965	1966	1967
No. of establishments class $5M or over	8	10	11	14	17	18	18	18	18
Average size in largest class	$17,098	$16,280	$15,708	$16,580	$16,368	$17,204	17,830	20,896	$20,888
% Total for largest 4									
a) all plants equal	34%	29%	25%	21%	18%	17%	17%	16%	16%
b) all but 4 = min.	59%	59%	55%	55%	59%	60%	58%	60%	60%
% largest class total	69%	72%	69%	73%	77%	77%	74%	74%	74%
Multiplant firms (No. of plants)									
Automatic Electric (Canada)	n.a.	2	n.a.	2	2	2	2	2	2
Can. General Electric	n.a.	2	n.a.	2	2	2	2	2	2
Canadian Westinghouse	n.a.	2	n.a.	2	2	2	2	2	2
I.T.T. (Canada)	n.a.	-	n.a.	-	-	-	-	3	5
Northern Electric	n.a.	2	n.a.	4	4	4	5	5	7
R.C.A. Victor	n.a.	2	n.a.	2	3	3	3	4	4

to $2,292,000. The largest two classes accounted for 81.6% of factory shipments and 17% of the number of plants in 1957 and 92.3% of shipments and 34% of the number of plants in 1967.

The increase in the number of plants in this industry occurred in these two large size classes. Entry into these two classes could have occurred either through the construction of new plants of these sizes or through the growth of existing smaller plants. Since the average plant in the largest size-class fell in relative size, most new plants must have been constructed at a smaller scale than that exhibited by the largest plants in existence in 1957 and the average entrant (through construction or growth) into the largest size-class must also have been of a smaller scale than the large plants of 1957. Between 1957 and 1960, two plants entered the largest size-class. If these two plants had entered into this size class at the smallest size possible i.e. $5 million in shipments, the two would have accounted for 4.5% of industry output. Therefore as a minimum estimate had there been no growth in the industry, the top four plants would have produced 39% of industry output in 1960 versus 34% for the top 4 in 1957. Since the largest 4 plants actually accounted for 29% of output in 1960, rather than 39%, the largest plants must have grown less rapidly than the industry as a whole.

Between 1957 and 1967 ten plants entered the largest size class, and the share of total shipments of this class increased by 5%. If all ten entering plants were at the minimum size of this class in 1967 or $5,000,000 in shipments each, they would have provided nearly 10% of industry output. Had the original eight members of this class

retained their relative share of industry output the total class would have accounted for 79% of total output in 1967 whereas they only provided 74%. We can therefore conclude generally that the plants in the largest size class in 1957 did not grow as rapidly as the industry as a whole. In fact, the largest plants in existence in 1957 grew at an annual average rate of 10.4% per annum (assuming all entrants to the largest size class were of the minimum size) as compared with an annual growth rate of the industry as a whole of 18.1% in this same period. This evidence does not of course show that the largest plants exhibited diseconomies of scale in this period. Growth rates of over 10% a year are certainly no evidence of diseconomies.

Wire and Cable -- Changes in Plant Scale

A similar analysis can be carried out for the electric wire and cable industry. Table 8 shows that, although the average size in the largest size-class grew, it also grew less quickly than the industry average. While the number of firms in this size class doubled, the share of industry total shipments accounted for by this size-class only grew from 86% to 92%. Therefore, the entrants to this size-class were at a smaller scale than the average size of the eight plants in existence in 1957. The remainder of the plants outside the largest size-class had a decrease in their output from 14% of the industry total to 8%. Since the number of plants with shipments less than $5,000,000 decreased with the period, it would appear that the minimum size plant necessary to remain in the industry is $5,000,000, with the average-sized plant in this largest classification shipping 6% of industry output or $18,000,000.

TABLE 9

Plant Data: Electric Wire and Cable Manufacturers, Value of Shipments of Own Manufacture

	1957	1960	1961	1962	1963	1964	1965	1966	1967
No. of establishments class $5M and over	8	8	8	10	11	11	13	15	16
Average size in largest class ($M)	14,300	$16,400	$16,500	$15,400	$15,300	$17,400	$19,000	$20,800	$18,200
%total for largest four									
a) all plants equal	43%	40%	40%	34%	31%	31%	28%	24%	25%
b) all but 4 at min.	74%	69%	69%	69%	68%	71%	73%	75%	70%
% largest class of total	86%	81%	81%	86%	86%	87%	90%	91%	92%
Multiplant firms (No. of plants)									
Canadian Westinghouse	8	n.a.	7	6	6	6	6	6	6
Northern Electric	1	n.a.	1	1	1	1	1	1	2
Phillips	3	n.a.	4	4	5	5	5	5	5

Multiplant Operations

In 1967, there were 6 multiplant firms in the communications-equipment industry, owning 22 plants in total as compared with 5 multiplant firms controlling 10 plants in 1957. Data are not available which would allow us to estimate the economies of scale or the concentration of output on the firm level for these 6 firms.[6/] All that can be said in this regard is that the multiplant firms introduced new plants at a rate faster than that of the industry as a whole and that no firm reduced the number of plants it owned.

In 1968, three firms - Canada Wire and Cable, Phillips Cable and Northern Electric controlled 13 plants, or 46% of the wire and cable industry total, the same percentage which the first two firms owned in 1957. While Northern Electric and Phillips each increased the number of plants owned, Canada Wire reduced its number of plants. Again, due to lack of data, analysis of the volume of output accounted for by the multiplant firms can not be undertaken.

Plant Production and Requirements Functions

In the chapter on the productive characteristics of telecommunications common carriers, production functions, and requirements functions were estimated from industry data. To remain consistent with that chapter, the same types of functions should be estimated for the manufacturing inputs as well. Unfortunately, however, the required data on capital services are not available and our attempts to derive

---

6/A description of the share accounted for by Northern Electric Company in both industries will be given in a later section.

labour requirements functions based on the cross sectional date over size classes, published by D.B.S., proved unfruitful. We therefore rely completely on the input-output approach to estimate the contribution made to production by the different factor services available.

4. The Large Firm

The two major suppliers of communications equipment are Northern Electric (100% owned by Bell Canada) and Automatic Electric (100% owned by General Telephone, whose other manufacturing subsidiaries in Canada are Lenkurt and Sylvania).

Northern Electric was established as a subsidiary of Western Electric in the early 1900's. In the mid-1920's Bell Canada purchased 49% of Northern Electric and until 1950 Bell remained a minority shareholder in Northern. In 1956, the Federal Trade Commission ordered Western Electric to abandon its dealings with companies which were not members of the A.T. & T. network, and Western Electric sold its 51% share in Northern to Bell Canada. Northern as a private company does not have to provide data to the public; since 1963, however, the company has published an annual report, and this is the basis for the data used in analyzing its share of the market.

Between 1961 and 1967, Northern Electric increased its sales of goods of own manufacture by 100%, whereas the two industries in which it operates saw an increase in output in the same period of 126%. Table 10 gives various estimates of the share of Northern Electric in the communications-equipment and wire and cable markets. Column (6) gives Northern Electric sales of own manufactured goods as a percentage of the value

TABLE 10

Northern Electric Company

Year	Sales (Total-$M) (1)	Sales (Mfg. goods) ($M) (2)	Plant Cost ($M) (3)	Number of plants (4)	Employees (5)	Plant/employees (3)/(5)	Sales/employees (1)/(5)
1959	236.1	165.7	78.2	3	15,290	$5114	$15,441
1960	250.7	180.4	90.0	3	15,583	5776	16,091
1961	238.0	172.4	99.5	3	16.099	6181	14,784
1962	281.8	201.2	111.2	4	16,904	6578	16,670
1963	302.5	219.8	119.7	4	16,849	7104	17,954
1964	315.8	225.9	131.4	4	18.011	7296	17,534
1965	358.1	249.6	146.3	4	19,632	7452	18,341
1966	400.2	284.1	167.2	5	23,864	7006	16,770
1967	403.3	308.1	185.3	5	22,557	8215	17,879
1968	426.3	345.3	195.7	5	23,682	8603	17,865

Source: All data except the number of plants: Northern Electric Company Reports, 1963-68

Number of plants: DBS Communications Equipment Manufacturers, Manufacturers of Electric Wire and Cable (sum of the two series)

of shipments of goods of own manufacture, for the two industries. This percentage declines from 41.6% in 1960 to 36.8% in 1967. If the relevant market to Northern Electric is considered to be the telephone-equipment market (as measured by DBS) then Northern's share of the combined telephone-equipment and total electric wire and cable markets is 65.9% in 1960 and 55.1% in 1966. The 1968 Northern Electric report lists the products manufactured by Northern as including telecommunications wire and cable and power wire and cable in the wire and cable category. Nortern's share of the combined telephone-equipment, telecommunications-wire and cable, and power-wire and cable market falls from 94% in 1960 to 83% in 1967. By whatever basis we measure Northern Electric's market, its share of the market fell substantially in the 1960's. This evidence is entirely consistent with the preceding analyses which showed a rate of growth for the largest plants which was less than the industry average.

5. SUMMARY -- Size, Economies of Scale

Concentration

The communications-equipment and electric wire and cable industries are highly concentrated both on a plant and firm level. Estimates in an early section indicated that the largest four plants in the communications equipment industry produced in 1967 at least 16% of industry output (if all plants in the largest size class were of equal size) and possibly 60% of output (if all plants but the four largest produced $5 million in shipments). Eighteen plants in 1967 produced 74% of industry output. In the wire and cable industry, 16 plants produced 91% of industry output with the four largest producing a minimum of 24%

TABLE 11

Value of Shipments (Goods of Own Manufacture)

(millions of dollars)

Year	Wire & Cable (1)	Telephone & Power Cable (2)	Communications Equipment (3)	Telephone Equipment (4)	Northern Electric (5)	(4)/(1)+(3)	4/(1)+(4)	4/(2)+(4)
1960	161	83	252	100	172	41.6%	65.9	94
1961	163	80	251	100	180	43.5	68.4	100
1962	181	83	311	121	201	40.9	66.6	99
1963	195	96	361	141	218	39.2	64.7	92
1964	227	108	402	150	226	35.9	59.9	88
1965	274	140	431	160	250	35.5	57.6	83
1966	341	169	507	175	284	33.5	55.1	83
1967	318	145	619	221		36.8		

Source: Wire + Cable -- Value of factory shipments electrical wire and cable -- DBS, Manufacturers of Electric Wire and Cable, 1960-67

Communications Equipment: Value of factory shipments goods of own manufacture, D.B.S., Communications Equipment Manufacturers, 1960-67

Telephone Equipment: Value of factory shipments, telephone materials (excluding intercommunication and inter-office communication devices) plus carrier current equipment, D.B.S., Communications Equipment Manufacturers, 1960-67

Northern Electric -- Company Reports, 1963-68

and possibly 70%. Multiplant firms exist in both industries to a significant degree. While data could not be obtained on the operations of these firms, the largest firm,Northern Electric,accounted for 37% of industry output in 1967 and possibly up to 83% of the output sold only to telecommunications carriers in that year.

While economies of scale are evident, at least from data on the growth rate of different size-classes, the shares of the largest plants and firms nevertheless appear to be falling. Economies of large size (which -- again, from the available data -- do not become diseconomies at the largest size), are therefore insufficient to prevent either new entrants or the growing smaller plants (and firms) from competing with the largest plants (and firms).

The conclusion that barriers-to-entry in the communications-equipment and wire and cable industries are minimal cannot be drawn with the available evidence. A complete discussion of the barriers-to-entry would include an analysis of the cost curves of various size plants in order to estimate the profitability of different sized operations. The evidence suggests less rapid growth on the part of the large medium-sized plants. It may well be true, however, that the largest plants continue to produce the most profitable items, while the more rapidly growing sectors of the market involve only marginally profitable products. Furthermore, the manufacturers who produce for the telecommunications market are a subsector of communications-equipment and wire and cable industries. While concentration is higher in this subsector than in either communications equipment or wire and cable, we cannot conclude

that economies of scale are either present or absent since a comparison between Northern Electric and its competitors has not been possible.

Hence, even our weak conclusions on scale economies in communications equipment and wire and cable cannot be applied to the subsector of these industries which manufactures strictly for the telecommunications market.

CHAPTER VIII

VIII. PROJECTIONS

1. Introduction

In this chapter we employ the statistical relationships estimated above to develop projections of certain key quantities in the telecommunications industry for the years 1975 and 1980. In particular, projections of revenue, labour, capital, and investment are given for each of the separate sectors -- telephone, telegraph, broadcasting, and also for Bell Canada. Where possible, projections are made for separate components of revenue, capital, and investment. All projections are in real terms.

As suggested in the flow chart of Chapter I, we begin with a set of real output projections. These are based upon the demand functions estimated in Chapter III, together with some assumptions as to future real GNP increases and price movements. Taking these projected output measures, we use the equations of the investment chapter to calculate gross and net investment for each sector for each year between 1968 and 1980. The sum of these net investments over time for a single sector represents the change in its capital stock from 1967. In the production chapter, functions relating output to inputs and technological change variables were introduced. We use these production functions, taking output as projected from the demand functions, and capital as developed from the projections of the investment chapter, together with appropriate assumptions as to the rate of growth of technology, to estimate the labour force in 1975 and 1980. The projections of investment demands for all three sectors -- telephone, telegraph and cable, and broadcasting -- are

then added together for each year to yield an estimate of the final demand for investment goods in any year. Calculating the construction component of this investment then allows us to estimate the derived demand for communications equipment and wire and cable manufacturers. Deducting the projected inports of telecommunications equipment then leaves the 1975 and 1980 output of domestic communications equipment and wire and cable sold to carriers and broadcast companies, the production of semi-manufactured materials, and the provision of primary factors. In this way we trace the impact of the final demand for output of telecommunications services back onto the input requirements of the telecommunications services sector itself, and through the communications equipment and wire and cable producing sectors (after deducting imports of these final product) to the inputs of domestic primary factors made necessary by the need to supply the telecommunications sector. So far as we can presently take it, our analysis of the impact of the communications sector on markets for labour and capital in Canada is then complete.

2. Demand projections

In order to make projections to 1980 it is necessary first to make assumptions about the growth paths of income, prices, and population. Independent estimates of income and population growth are beyond the scope of this study, but have been undertaken elsewhere; in particular, the Economic Council of Canada has made such estimates in its 1969 report Perspective 1975. The Council predicts 5.5% per annum real growth in GNP to 1975 and we have accepted this optimistic estimate. For the period 1975 to 1980 we have been somewhat more conservative, assuming a real growth rate of 5.0% per annum. Where an absolute price level is necessary we have assumed inflation of 2.0% per annum in the GNP deflator. For projections from equations which use measures of income other than GNP (e.g. PDI or PCE), we have assumed that these grow at the same rate as GNP.

The Economic Council has based its GNP estimates on a rate of growth of population of 1.7% per annum to 1975. We have assumed that this rate will continue to 1980.

Assumptions about the trends in prices of telephone services are more difficult to make. In the period 1960 to 1967 there were no changes in Bell Canada's local service rates and there was a decrease in long-distance rates that averaged 1.7% per annum. Bell has recently applied for an increase in local-service rates, so the 1960-67 period is not representative of the future. We have assumed that on the average over our forecast period local-service rates will increase at 1% per annum and that long-distance rates will decrease at 1% per annum. Since we have assumed that the GNP deflator

will rise at 2% per annum, our assumptions imply that the price of local service relative to other goods and services will fall at 1% per annum and the relative price of long-distance service will fall at 3% per annum. In equations estimating total telephone revenues, we used a weighted average of local and long-distance rates (.55 for local and .45 for long-distance) which results in a composite relative price declining at 1.9% per annum for total telephone.

Using the assumptions just stated, the demand for telephone service and various of its components in 1967 dollars is projected at the levels shown in Table I. These projections show telephone continuing to be a rapidly growing industry, with long-distance revenues growing at a more rapid rate than local revenues in the future as they have in the past. Since we have assumed long-distance rates to fall 2% faster than local rates, with compounding this amounts by the end of the period to a cumulative 29% fall in long-distance rates relative to local rates.

In order to see how sensitive our projections are to the GNP and price assumptions employed, we recalculated the forecast for total telephone on the basis of some "pessimistic" assumptions. Our "pessimistic" GNP assumption allowed only 4.5% growth per annum to 1975 and 4.0% thereafter. The "pessimistic" price assumption allows the relative price of telephone service to fall at .9% per annum rather than 1.9% per annum. Substitution of the pessimistic GNP assumption alone results in a reduction of 162 million dollars per year in our 1980 revenue prediction and the pessimistic price assumption alone lowers the 1980 prediction by 145 million dollars per year. When both pessimistic assumptions are used together, predicted 1980 revenues fall by 307 million.

TABLE I

Projections for the Telephone Industry (millions of 1967 dollars unless otherwise indicated)

	1967 (actual)	1975	1980	eqn. used in projection
Total revenue	1164	2261	3110	eq.4, Ch.III
Local revenue	612	1088	1489	eq.5, Ch.III
Toll revenue	461	964	1344	eq.6, Ch.III
Total Capital Stock	4295.6	9239.4	12924.9	eq.1, Ch. V
Stock of equipment	2726.0	6214.6	8865.1	eq.3, Ch. V
Stock of construction	1569.6	3078.8	4151.0	eq.3, Ch. V
Number of employees ('000)	68.0	74.4	89.6	eq.6, Ch. IV
Manhours (million)	108.8	130 .1	143.3	eq.6, Ch. IV
Total investment	582.0	974.8	1184.3	eq.1, Ch.V
Net	446.1	684.0	771.1	eq.1, Ch.V
Replacement	135.9	290.9	413.2	eq. 1, Ch.V
Investment in Equipment	398.0	682.3	839 7	eq.2, Ch. V
Net	312.8	487.6	557.3	eq.2, Ch. V
Replacement	85.2	194.7	282.5	eq. 2, Ch.V
Investment in Construction	184.0	289.6	339.4	eq.3, Ch. V
Net	139.8	203.3	221.5	eq. 3, Ch.V
Replacement	44.2	86.3	117.9	eq. 3, Ch.V

We have also projected total Bell Telephone revenue using equation (18) of Chapter III. Our procedure assumes that Ontario and Quebec income will grow at the same rate as national GNP and that the relative price for Bell services will fall by 1.9% per annum. Our projections (see Table II) suggest a total revenue for Bell of $1244 million in 1975 and $1681 million in 1980, compared with the actual value of $702 million in 1967. The projections imply that Bell's share of total telephone industry revenue in 1980 will decrease somewhat from its 1967 level (54.1% in 1980 vs. 60.3% in 1967).

We see from Table III for the telegraph and cable industry that telegraph revenues are also projected to grow rapidly, though at a somewhat slower rate than telephone.

For the broadcasting industry, we have projected total advertising revenue using equation (1) of chapter VI. This equation was estimated using current dollar GNP which we assumed would grow at 7.5% to 1975 and 7.0% thereafter. We then deflated the estimates to 1967 dollars, by assuming that inflation in the broadcast industry will proceed at 2% per annum. Broadcast revenues are projected to rise from 200 million in 1967 to 325 million in 1975 and to 428 million in 1980 (all 1967 dollars). This estimate, however, somewhat underestimates the importance of the sector since it excludes non-broadcasting revenue and government grants. While both of these components have been rising faster than advertising revenues, we are reluctant to assume that this trend will continue in view of the government's present and prospective

TABLE II

Projections for Bell Canada (millions of 1967 dollars unless otherwise indicated)

	1967 (actual)	1975	1980	equations used in projection
Total revenue	705.6	1245.0	1681.4	eq.19, Ch.III
Total capital stock	2464.5	5793.1	8569.7	eq. 4, Ch. V
Number of employees (000)	36.8	43.8	48.6	eq. 6, Ch. IV
Manhours (million)	58.4	70.2	78.3	eq. 6, Ch. IV
Total investment	582.0	615.7	775.5	eq. 4, Ch. V
Net	259.8	493.8	592.0	eq. 4, Ch. V
Replacement	56.7	121.9	183.5	eq. 4, Ch. V
Investment in equipment		432.2	552.2	*
Investment in Construction		183.5	233.3	*

* Values calculated using the proportions recorded for the telephone industry as a whole.

stance on inflation. Consequently, we have assumed that the proportion of total revenue that grant and non-broadcasting revenue contribute will remain at the 1968 level. Thus, we project total broadcast industry revenue in 1980 to be 756.9 million 1967 dollars.

To project the capital stock in 1980, we began with the observations that in 1968 the industry had a gross capital-output ratio of 1.154 and that this was rising at 1.0% per annum. We then projected a capital-output ratio of 1.30 in 1980. In 1968, the ratio of technical and studio equipment to output was .699 and was rising at 1.7% per annum. Assuming this trend to continue, we therefore project an equipment - output ratio of .85 for 1980. Taken together these assumptions yield a gross capital stock in 1980 of 984 million 1967 dollars, of which 643 million is projected to be technical and studio equipment. In the period from 1962 to 1968 we estimated the average investment at $26.6 million annually, of which 17.8 million is in technical and studio equipment. The total capital stock and stock of equipment at the end of this period were 321 and 203 million dollars, respectively. Assuming that the ratio of average investment to capital stock will prevail in the projection period we project an average annual investment of 81.5 million 1967 dollars of which $56.4 million is for equipment. Table IV sets out these estimates for the broadcasting sector.

TABLE III

Projections for Telegraph and Cable Industry (millions of 1967 dollars unless otherwise indicated)

	1967 (actual)	1975	1980	equations used in projection
Total revenue	104.5	191.1	267.7	eq.19, Ch. III
Stock of capital	346.6	581.8	765.5	eq. 5, Ch. V
Number of employees (000)	8.9	9.2	9.6	eq.19, Ch. IV
Total investment	28.5	46.3	55.4	eq. 5, Ch. V
Net	19.9	33.7	38.6	eq. 5, Ch. V
Replacement	8.6	12.6	16.7	eq. 5, Ch. V
Investment in equipment		32.4	38.8	70% of the total
Investment in construction		13.9	16.6	30% of the total

TABLE IV

Projections for the Broadcasting Industry (millions of 1967 dollars unless otherwise indicated)

	1968*	1975	1980	equations used in projection
Total revenue	209.9		756.9	+
Advertising revenue	161.2		428.0	eq. 1, Ch. VI
Non-broadcasting revenue	371.2	325	328.9	+
Capital stock			984	+
Technical and studio equipment			643	+
Total investment			81.5	+
Inv. in technical and studio equipment			56.4	+

* in current dollars

+ see text.

3. Capital and Investment projections

Projections of flows and stocks of capital have been undertaken separately for telephone, telegraph and cable, and Bell Canada by employing the equations estimated in the text of Chapter V. For output, we have used actual revenues for 1965-67 and projected revenues from 1968 to 1980. Thus the assumptions adopted in projecting revenues directly affect our projections of investment outlays and stocks of capital.

From the figures in Table I we see that the telephone industry is projected to continue to expand its capacity steadily in the next decade or so, but at a considerably slower rate than that between 1950 to 1967. Investment outlays measured in constant (1967) dollars are projected to rise from $582 million in 1967 to $974.8 million in 1975 and $1,184.3 million in 1980, implying an average rate of increase of 4.7% per year as compared with the 7% which prevailed in the 1950-67 period. Since about two-thirds of capital expenditures in this industry go into expansion in capacity as distinct from replacement, the capital stock of this industry measured in constant (1967) dollars is projected to swell from $4.296 million in 1967 to $12.925 million in 1980, a three-fold increase.

To estimate the composition of flows and stocks of capital for the telephone industry, we have projected its two components independently from equations (2) and (3) in Chapter V. We find that while investment outlays on both the machinery and equipment category and the construction category will grow continuously, equipment outlays will outpace construction, reflecting a continuation of the gradual shift of investment outlays from construction to

equipment already occurring. For instance, investment on equipment and machinery is projected to be $840 million in 1980, which is 71.2% of the total capital outlays in that year, compared with 70% for 1975 and 65.4% for 1967.

Total capital formation by Bell Canada in 1980, measured in 1967 dollars, which has been projected by using the Bell investment equation [equation (4) in Chapter V], is projected to be about $776 million. This value suggests that Bell will expand its capacity roughly at the same rate as does the telephone industry as a whole and thus that Bell's share in the indsutry's demand for capital goods will be stable at about two-thirds of the total. It is interesting to note however, that Bell is projected to spend a larger proportion of its investment for expansion than the industry as a whole. Consequently, the projected rate of growth in capital stock for Bell is slightly above that for the industry. Available information does not permit us to make independent estimates of the composition of investment outlays for Bell Canada as we did for the telephone sector as a whole. The split was obtained simply on the assumption that Bell, being two-thirds of the industry, will reflect the same division in investment outlays as is observed for the industry as a whole. In this case, $423 million of 7.12% of the total investment outlays will be spent on equipment by Bell in 1980.

Projections for the telegraph and cable industry have been obtained from equation (5) in Chapter V. From Table III it is seen that investment outlays measured in 1967 dollars by this industry are projected to continue to increase in the next decade to $55 million, nearly double that in 1967. On the average, investment outlays by telegraph and cable are projected to grow slightly more rapidly than for the telephone industry; on the other hand, telegraph is projected to devote relatively more investment to replacement than

that for the telephone industry. This seems quite reasonable in the light of the fact that telegraph and cable has much older plant than telephone. As was the case with Bell Canada, we are unable to make independent estimates of the split in investment between equipment and construction. Therefore, what we have done is to assume a split based on the average distribution of the projected investment for the telephone industry for the period of 1968-80, 70% for equipment and 30% for construction.

4. Labour projections

To project the labour requirements for Bell Canada we use the value - added production function equation (6) in Ch. IV, since this equation has the best theoretical and statistical properties of the equations estimated in that chapter.[1]

The equation shows value added (V) as a function of labour (L), capital (K) and the percentage of calls dialed by the customer (D). To project labour input requirements it is therefore necessary to have projections of V and D. Revenues and the capital stock have already been projected. Consequently the additional information needed is an estimate of raw materials costs and indirect taxes in future years, and the growth rate of the technology variable (D_t). Raw materials and indirect taxes amounted to 19% of constant dollar revenue in 1967 and 24.7% in 1952. We assume that raw materials plus indirect taxes will amount to 15% of revenue in 1975 and 13% in 1980. The index D_t, the percentage of toll station-to-station calls dialed by the customer, grew at an average rate of 4.75% in the period 1952-67. If this rate of increase were to continue until 1980, this index would be 95% in that year,suggesting that nearly all residents will have direct distance dialing facilities available to them. Since this figure seems rather

---

[1] The version of equation (6) employed in these projections is that based on the original revenue series calculated by Olley, op.cit., rather than on the revenue series deflated somewhat differently, from which equation (6) of Ch. IV was finally estimated.

high, we have decided to lower the assumed rate of increase of D_t to 2.50% per year over the forecast period. At this rate of growth, D_t rises to 66.5% in 1975 and 75.2% in 1980.

In 1967, Bell employed 58.4 million manhours. Our projections show that the number of hours worked will grow at 1.18% per annum to 1975 and at 1.62% per year between 1975 and 1980, with the number of manhours worked being 70.2 million in 1975 and 78.3 million in 1980. In 1967, the average employee worked 1600 hours per year. Assuming that this figure will remain constant, we thus project there to be 43,800 employees in 1975 and 48,600 in 1980.

The number of manhours and employees in the telephone industry as a whole has been projected in two ways: (1) by using the Bell value-added equation (6), combined with projections of industry value-added and industry capital and (2) by simply increasing the Bell employee projection by the ratio of total industry employment to Bell Canada employment for 1967. The two methods yield nearly identical results.

Since the Bell Canada value-added production function is statistically the best production function estimated and since no evidence was uncovered to suggest that this production function could not be used to describe industry aggregate behaviour, our projections of industry employment use this equation. The estimates of revenue and capital stock are taken from preceding sections of this chapter. Raw materials and indirect taxes are assumed to be 17% of industry revenue in 1975 (slightly higher than Bell Canada) and 14% in 1980. The technology trend term D_t, is expected to grow at the annual rate of 2.50% per year (the same rate as for Bell Canada).

On the basis of these assumptions, the number of manhours worked in 19

is projected to be 130 million and in 1980 to be 143 million, compared with an estimated 109 million in 1967.[1] Total manhours are therefore projected to grow at an annual rate of 2.4% between 1967 and 1975, and 2.1% between 1975 and 1980.[2] The number of employees, estimated by dividing the number of manhours by the total annual hours per employee (1600 hours), is 119,100 in 1975 and 143,300 in 1980. As was suggested, projections of total future telephone employment can also be obtained by adjusting the estimates of Bell hours worked by the ratio of total employees to Bell employees in 1967. This technique leads to estimates of 129 million hours in 1975 and 145 million hours in 1980 for the total telephone industry.

The labour force projection for the total number of employees in the telegraph and cable sector is made by using equation (19) of Chapter IV. This forecasting equation estimates the number of employees directly as a function of revenue, time, and the percentage of revenue from non-transmission sources. In addition to the revenue estimates for telegraph made earlier in this sector, we must project the percentage of revenue from non-transmission sources. In 1967 transmission revenue was 60% of total revenue. We project this percentage to grow to 66% in 1976 and 70% in 1980. The total number of employees is projected to reverse its downward trent and rise to 9,200 in 1975 and 9,600 in 1980 from 8,900 in 1967.

---

[1] This 1967 value for manhours is estimated by multiplying the number of employees by 1600 hours per employee.

[2] The rate of growth projected for industry employment is higher than that for Bell Canada alone because our previous projections suggest that Bell will have higher capital stock growth and lower output growth than the total industry.

5. The impact of the projected investment outlays by the industry on the Canadian Economy in 1980.

In this section, the projections of the investment demands on machinery and equipment (including wire and cable) are added together and their impact on the Canadian economy in 1980 is discussed.

The 1968 output (in 1968 dollars) of communications-equipment manufacturers was $675,000,000, while wire and cable producers shipped $323,000,000 worth of products. The Canadian Electrical Manufacturers Association has forecast that communications equipment shipments (including imports) will increase by 10.4% (8.9% in constant dollars) per annum, and that wire and cable shipments (including imports) will increase at a rate of 8.0 per cent (6.5% in real terms) per annum up to 1975.[1])

Projecting the constant dollar value of domestic shipments in 1980 for both these industries using the annual rate of increase forecast by the C.E.M.A. yields shipments of $1,880,000,000 for communications equipment manufacturers and $688,000,000 for wire and cable producers in 1980.

We take as our 1980 final demand estimate, for these two industrie combined, the projection of constant dollar investment (less construction) mad earlier in this chapter for telephone ($840 million) telegraph ($36 million) and broadcasting ($54 million) or a total of $930 million. Before estimating the impact on domestic producers resulting from this projected expenditure, however, the amount of this investment which is directly met by imports must be deducted. Two estimates of the direct import content of final demand are

---

[1]Canadian Electrical Manufacturers Association, Goals to 1975, (Toronto, 1970)

TABLE V

Impact on Domestic Equipment Producers of the 1980

Projected Investments in Telecommunications

	(1)	(2)
1980 Total investment expenditures telephone, telegraph, broadcasting	$930.3	$930.0
Percentage of direct imports	33.4	24.3
1980 domestic investment expenditures telephone, telegraph, broadcasting	$619.	$712
Impact On		
Wages	$353	$406
Surplus	$155	$ 78
Indirect taxes	$ 12	$ 14
Metals	$180	$206
Manufacturing	$ 87	$100
Services	$136	$157

used. The first - 33.4% - is the value given as the import coefficient in the 1961 input-output tables for Canada. The second value - 23.4% - is the average (1961-67) percentage of imports to the total value of electrical products shipments as given by the Canadian Electrical Manufacturers Association.[1] The following table (Table V) gives the estimates of the impact of the calculated final demand for telecommunications equipment in 1980 using the import coefficients of Table II in Chapter VII.

Domestic producers in 1980 are projected to be shipping between $620 and $729 million of equipment to the telecommunications sector. These shipments will lead to a direct and indirect wage bill of between $350 and $400 million, profit of between $155 and $178 million, and indirect taxes of some $13 million. And as a result of the investment demands from communications carriers and broadcasters, the metals, man-facturing, and service sectors will produce roughly $190 million, $90 million, and $145 million, respectively, of materials for the communications-equipment industry.

With these projections we have completed the cycle of analysis laid out in Chapter I. Let us now turn in the final chapter to a summary of the results of the analysis and conclusions to be drawn.

---

[1] Goals to 1975 (Toronto, 1970)

IX. Conclusion

"This voyage of MacKenzie's ... is a record of carefully maneuvered and exquisitely conserved effort in the face of a terrain so vast, so absurd, so all-absorbing that effort, except to subsist, seems useless, and yet a terrain across which, driven by some vision or compulsion, men continually string out, from point to point, the means of communication. Beneath the apparent rationality, the commonsense search for commercial advantage, we sense a ruling passion which is not explicable in these terms..."[1]

To travel the vastness that is Canada is to appreciate the accomplishment of those who built the paths which link this country from sea to sea, first along the tracks of the birch bark canoe, later over steel rails, or along wires hung on wooden poles, now carried on beams from tower to tower, soon, perhaps along a path to satellite and back. Their achievement is great, and they can justly claim that this country has been well-served by its communications industries.

But this present study must, by its nature, carry out its analysis of the telecommunications sector only on the basis of the apparent rationality, the commonsense commercial advantage, presumed to drive the industry forward; in so doing, it must to some extent fail to measure adequately the magnitude of the achievement entailed in bringing telecommunications in Canada to its present development. As well, it perhaps may fail to measure adequately the importance of that accomplishment to those

---

[1] Daniells, Roy. Alexander MacKenzie and the North West, London: Faber and Faber, 1969, p. 90.

who in various ways depend upon the sector not just for data or for instructions, but for human expression, for a link with a community, for warning, sometimes for rescue. It is not that we think these things unimportant; rather we simply know no way, within a statistical background paper, to gauge and explain the significance of these factors in the development of the industry or the nation. We fall back, therefore, upon "apparent rationality and common sense commercial advantage", and in this decision our terms of reference support us.

We, as statisticians or economists largely innocent of telecommunications technology, cannot aspire to teach the firms in this business how to do their job better, or even how to serve the public better. Nor do we aim to do so. Rather, from a position outside the firms, and outside the industry, we hope to show the sector as a unit in the Canadian economy as a whole. Looking in from the outside, we may, with luck, achieve some overall perspective that is denied studies centered on the outlook for a single firm. At any rate that, rather than definitive recommendations as to how individual firms should behave, has been our goal.

Our terms of reference emphasize statistical background, leaving aside issues of policy or regulatory goals, and this study conforms strictly to that emphasis. We solve no policy problems, and make no recommendations here. We have occasionally commented upon policy issues that appear to us to require further study or made a note if our statistical results suggest the presence of policy problems to come, but we have not pursued these issues.

We have tried simply to establish a consistent model of the telecommunications sector, taking an overall economic environment as given, and tracing the flows of goods and services into and out of the sector. But the scale of our undertaking was not large, and the constraints on time severe, at least by academic standards. At the outset it was recognized that many points which it would be desirable to investigate must be left unexplored simply because time did not permit development of the necessary data series or background information. Our terms of reference recognize this limitation also, and imply some assurance that further work will follow down some of the roads to which our study points.

With these qualifications, then, that we recognize the industry to be more than statistics, both in its thrust to build and in the importance users may attach to its services; that we seek an overall perspective based upon an aggregate statistical framework rather than detailed forecasts of individual firm prospects; that we leave aside, as beyond our assignment, assessment of present or potential policy problems; and that we omit discussion of many relationships which would deserve study in a more extensive analysis -- with these reservations in mind, let us now go on to summarize what we see as the main points of our analysis.

There is, in scattered places, a substantial amount of information relating to the telecommunications sector of the Canadian economy. To learn anything from this information, we must impose some form, some organization, upon it. The organization we have adopted emphasizes the role of the sector as a whole as a supplier in markets for services provided to households, government, and industry, and as a buyer in markets for

labour services and capital equipment.

With this organization, this report has provided an extensive statistical description of the past two decades of growth in the telecommunications sector. The main points of this description are:

a) on the demand side

The demand for telephone installations is strongly affected by per capita income as well as by demographic factors, and rising incomes will lead to continuing increases in the number of telephones (including extensions) per 100 households.

The demand for telecommunications services (excluding broadcasting) is not sensitive to (that is, is inelastic with respect to) price, except for household long distance calling. (The demand for broadcasting services, being a purchased input into production activities, might be expected to be more sensitive to price, but we have been unable to detect such sensitivity.)

. The demand for telecommunications services displays substantial income elasticities in the long-run.

. In the short run, the demand for telecommunications services is characterized by substantial inertia and relatively strong habituation, and is insensitive to cyclical swings. The long-run impact of income changes is thus generally much greater than the short run.

The demand for telephone service (and presumably also

telegraph service) is homogeneous across regions once differences in income, population, and price have been taken into account.

- Demands for the fastest growing (data transmission) services begin from a sufficiently low base that they are unlikely to overwhelm conventional telecommunications services within a decade, even though extremely high present growth rates are observed.

b) On the production side:

- Telecommunications services are produced within a highly capital-intensive process employing a labour force with rising skill levels, and with only modest intermediate inputs, mostly of an overhead variety.
- There is strong evidence of decreasing unit costs as output expands, but we cannot identify the specific activities giving rise to these economies nor determine whether they are true economies of scale or arise simply from increasing utilization of overhead plant.
- Production decisions cannot be systematically explained simply as a response to changing wage/rentals ratios observed in markets for labour and capital, and this result is consistent with what one expects of a regulated sector.
- Continuing technological change, which can be represented in part by an index showing the percentage of station-to-station calls dialed by the customer in the case of telephone,

or the percentage of revenue accounted for by non-transmission (leasing) revenue in the case of telegraph, is apparent in the sector, and significant in explaining rising outputs or labour productivity.

c) On the investment decision:

. The investment decisions of the sector can be best explained by a distributed lag 'accelerator' model based upon a fixed target ratio of capital to anticipated output, with an average adjustment time of approximately two years.

. Cost of capital considerations appear to have little direct impact on investment decisions, and this, too, is a result consistent with the regulatory environment. The simultaneous presence of a smooth production function and an accelerator investment model is not theoretically inconsistent: when the durability of capital equipment is taken into account, the impact of regulation is seen to fall at the stage of the investment decision, not at the stage of the production decision determining the input of variable factors.

d) On the broadcasting sub-sector:

. Very low capital/output ratios characterize the broadcasting activity (because the required communications facilities are generally leased, and the receiving equipment is owned by the audience itself).

. Income elasticities computed for revenues of broadcasters show that advertising revenue is growing faster than GNP, and that

local advertising is growing faster than national. National advertising expenditures for broadcasting, however, respond more quickly to changes in GNP.

e) On the manufacturing sub-sector:

. As is to be expected, communications manufacturing is raw materials-intensive relative to communications services.

. Import leakages are significant both in electric wire and cable and communications equipment manufacture, particularly so in the latter.

. The rate of growth for the largest plants in communications equipment manufacture is less than the industry average.

. Data on growth rates of different size classes suggests some evidence of economics of scale in these manufacturing operations.

We shall not deviate from a long tradition dictating that at this point in our report we refer to the tasks remaining for subsequent analysis. We have touched upon many such already, and most of them may be summarized in the observation that we should like to see construction of a full model of the telecommunications sector, suitable to be integrated with macroeconomic models of the type under construction jointly or independently within several agencies of the Federal government. We have made a start at laying out and analyzing the real flows through such a model, taking into account demand, production, and investment decisions within communications services and communications equipment manufacturing. One should also attempt to develop relationships explaining wage determination within the sector (or from outside), price determination through the regulatory process, financial decisions determining dividend payouts and retentions (and the extent to

which these may be influenced by investment intentions), costs of capital or the return to capital required to sustain the growth of the system, and thus the feedback of costs and revenues on to the capital markets through their influence on capital requirements. In addition, our present analysis of production decisions should be elaborated to deal with the system explicitly as a network structure, and this elaboration, together with regional population projections being developed at DBS and elsewhere, would at the same time permit estimation of demand functions from a simple gravity model such as already been applied to U.S. telegraph traffic.

The extent of regulation or other government intervention (beyond the usual role of establishing the legal framework for operation) is formidable in the telecommunications sector. In telephone operations one has the direct participation of publicly owned systems, as well as regulation of federally chartered companies by the Canadian Transport Commission under the authority of the Railway Act and provincial systems by provincial regulatory bodies; in telegraph operations one has a division of a crown corporation (CNR) acting on its own and in association with a division of Canadian Pacific, a private corporation, with telegraph rates and tolls regulated again by the CTC; both telegraph and telephone systems feed into Canadian Overseas Telecommunications Corporation, a crown corporation, for all overseas messages. On the broadcasting side, the publicly owned CBC dominates both radio and TV, while cable and CATV companies are regulated by the CRTC under the authority of the Broadcasting Act. Revenues from telecommunications equipment manufactured by Northern Electric are consoli-

dated with Bell Canada revenues for purposes of establishing an overall rate of return, even though that operation is not otherwise regulated. Computing activities, with a growing link to communications, involve many companies, among whom can be numbered CN-CP and Polymer Corporation, a crown corporation. As well, government involvement in computing activities includes the Central Data Processing Bureau, and the support through the National Research Council of numerous university computing centres.

Policies, therefore, are already in force, and extensive intervention is already with us. A passive "low-profile" policy is no longer an option, if, indeed, it ever was in this sector. Under these circumsrances, it is our hope that this report will provide statistical background of use to those charged with making many of the important decisions to come within this sector.

TELECOMMISSION

Study 2(b)(ii)

Household Demand for Telecommunications Services – A Projection to 1980

The Department of Communications

STUDY 2 (b)

HOUSEHOLD DEMAND FOR TELECOMMUNICATIONS SERVICES

- A PROJECTION TO 1980 -

by

L. I. BAKONY

Available by mail from Information Canada, Ottawa,
and at the following Information Canada bookshops:

HALIFAX
1735 Barrington Street

MONTREAL
1182 St. Catherine Street West

OTTAWA
171 Slater Street

TORONTO
221 Yonge Street

WINNIPEG
393 Portage Avenue

VANCOUVER
657 Granville Street

or through your bookseller

Price $1.75 Catalogue No. Co41-1/2B

Price subject to change without notice

Information Canada
Ottawa, 1971

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

I. Introduction and Overview

This study explores growth and change in household requirements for telecommunication services in Canada in the decade of the 1970's. Telecommunications, with respect to the household sector, are defined in this study to include telephone and telegraph services, that is, services which essentially provide two-way communication. At the present stage, therefore, cablevision services are not included.

The procedure followed is to construct a model which includes three sectors. These are a demographic sector, a potential output or GNP generating sector, and a sector representing the household demand for telephone and telegraph services. The demographic sector model generates labour force data which are inputs to the GNP generating sector and it generates household data which are the principal explanatory variables in the demand equations. The methods used in developing demographic projections are described in Section III.

The GNP generating sector, hereafter called the potential output sector, provides the necessary projections for the overall level of economic activity in Canada. These projections are the type known as "potential" output projections. The state of the art of economic forecasting does not enable the construction of decade forecasts which incorporate short term cyclical fluctuations of the type represented by the decline in economic activity currently occurring in 1970. Potential output forecasts may therefore be "wrong" in either direction at various

points in the business cycle.

On the other hand, however, the communications plant is large and complex and is, by its nature, unable to adjust, except possibly in minor ways, to the vagaries of the cycle. Therefore, analysis of policy on the basis of potential levels of economic activity is not only necessary but seems also the wiser course of action.

The potential output sector model is essentially an aggregate production function. The production process represented takes account of labour and capital inputs and also of certain related phenomena which will be important to the Canadian scene in the period under study. These include the changing age-sex composition of the labour force which will be particularly dramatic, and the changing average level of education. Explicit account is taken also of technological change and economy-wide scale effects. Since these procedures have a major effect on the projections developed, they are described in detail in Section III.

The two components of our process described above, although of considerable interest in themselves, are essentially raw material for the final process described in Section IV. In that section demand equations are specified for telephone use by households. Separate equations are estimated for local service and for toll use since it seems likely that the parameters in these two areas will be substantially different. The equations are then used to project per household expenditures in constant dollars on the two categories of service to 1980. These projections are converted to aggregate total expenditures by multiplying the per household figures by the number of households and adding the resulting figures for the two classes of service to obtain

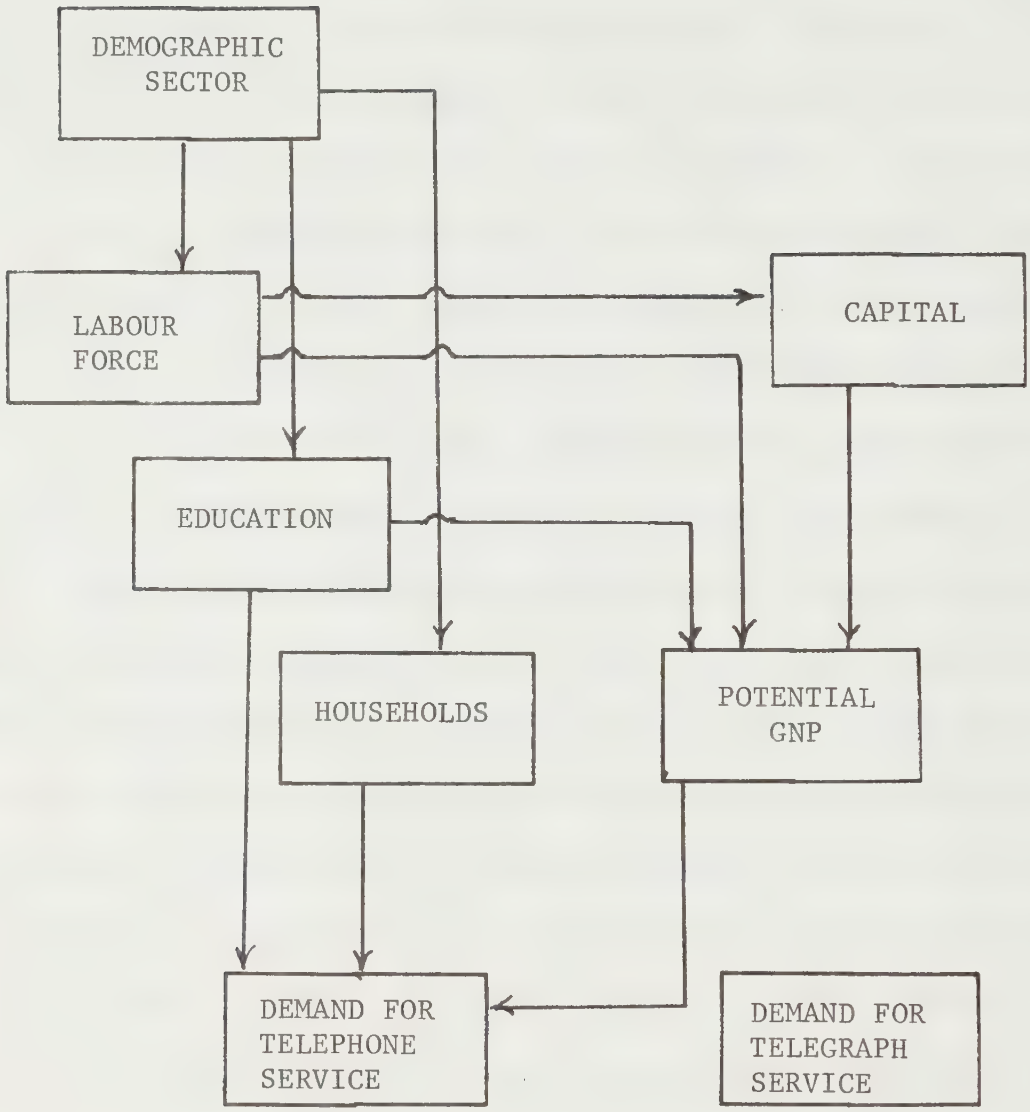
a total.

The case of telegraph service is handled in a simpler manner. Because of data limitations it has not been possible to isolate household use from total use. Total or aggregate demand for telegraph use has therefore been projected to 1980 by trend extrapolation. The proportion calculated by applying a ratio derived from samples of the message mix is then applied to the extrapolated figures to obtain an estimate of the household component of demand. This is a rough procedure, but fortunately the component of demand is relatively small. The objective is to place telegraph service in perspective with telephone service.

The skeletal structure of the procedures summarized in the preceding paragraphs is illustrated schematically in Figure 1.1. For example the demographic sector model is shown as generating the labour force, the education stock, and the number of households. These variables, in turn, feed into the telecommunications demand sectors either directly or indirectly via the GNP generating sector. The reasons for setting up and presenting the study in this way are in part reasons of expository convenience but are more essentially related to research technology. A study of this type can be programmed for an electronic computer from the initial introduction of raw data through the various intermediate steps to the final demand projections. Once such a programme exists, alternative assumptions can be easily introduced, more recent data may be incorporated or the model may be expanded in size or scope.

A prelimary word on data is required in a study of this type.

FIGURE 1.1



A Schematic Diagram of the Study

For the most part, the data used are from standard sources published by the Dominion Bureau of Statistics. The key set, however, has been provided through cooperation of the industry. Most of these data are previously unpublished. This study could not have been undertaken without these data. It must also be recorded that the quality of the projections is dependent in large part on the quality of the industry data. It should be noted that industry coverage, although broad, is incomplete for the telephone industry. Data covering about 85 per cent of revenues were used in the regressions reported here.

Because of the importance of the data to the results and because of their intrinsic interest, they are displayed graphically at the company level in Appendices B, C and D.

The reader whose interest is primarily in the projections themselves may turn immediately to the results and conclusions in Section V. The methods employed are described in Sections II, III and IV, and additional detail on data and sources is found in the Appendices.

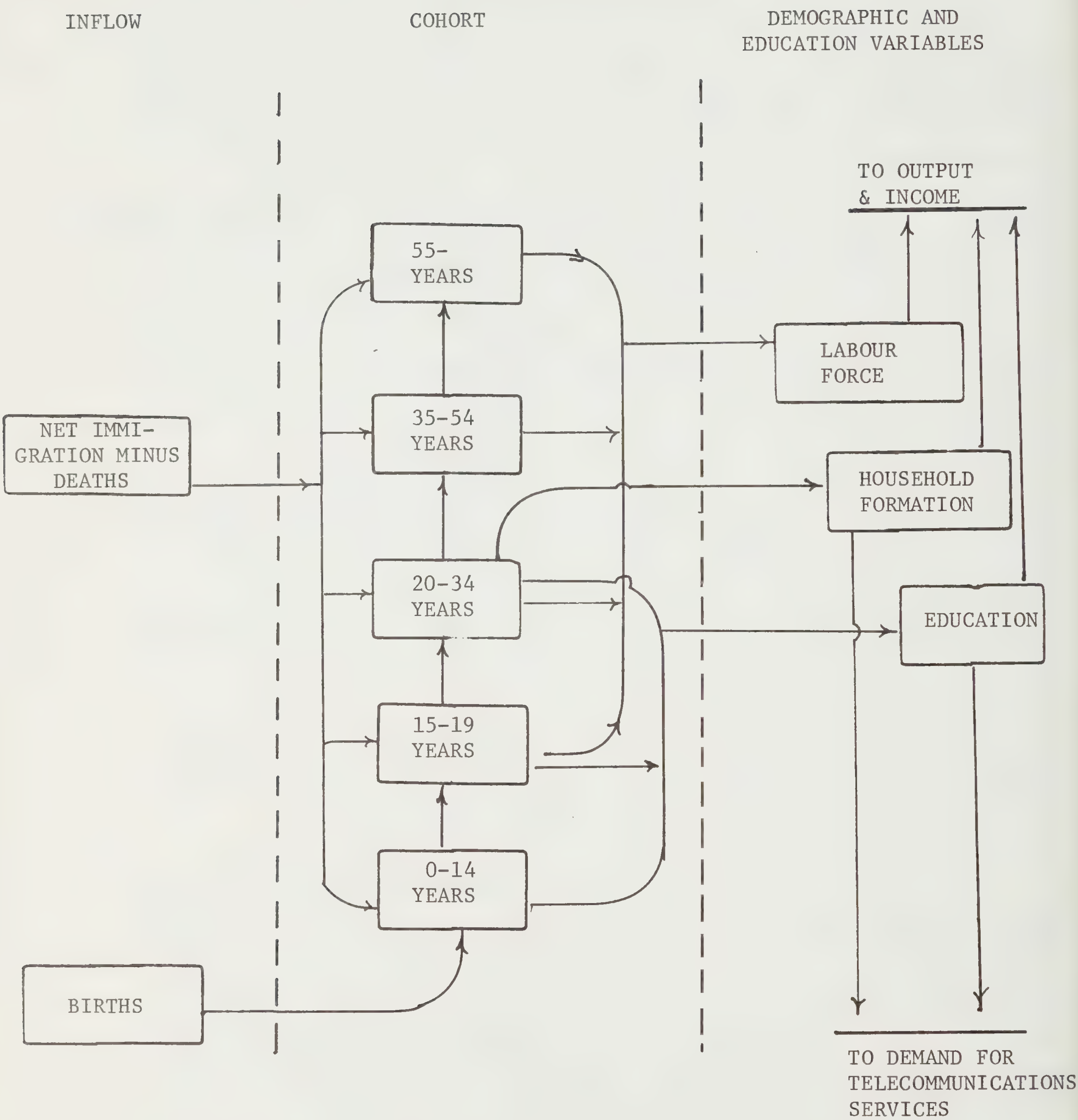
II. The Demographic and Education Sectors

1. The Demographic Sector

Given the objectives of the study and the nature of the industry under examination, it is inevitable that, irrespective of the method of analysis employed, demographic movements will be of paramount importance in developing the projections reported here. Detailed attention is therefore paid to the definition and measurement of the demographic variables used in the study. Because of the complexity of the calculations, however, some short cuts in exposition seem desirable. The basic technique employed is the cohort-survival method (sometimes referred to as the "component method"). In this approach a "bench-mark" population is taken as the beginning point. This population, obtained from census data, has the classification relevant to the study at hand; for example, different aspects of the present study require breakdown of the population by age group, by sex, by education level, etc. The bench-mark population is the so-called "cohort". The cohort is followed through the desired time span (1950-1980) by addition of the annual net inflow; for example, births plus net immigration minus deaths in the case of the population cohort. This process is illustrated schematically in Figure 2.1.

It will be noted from inspection of this figure that the population is divided into five age groups. Each age group is divided into the subgroups male and female. The lower three age groups (both sexes) are inputs to the education process; the middle group (20-34 years) provides the principal input to the household formation process; and all age groups excluding the lowest (0-14 years) constitute the labour force

FIGURE 2.1



The Demographic Sector

source population.

This basic demographic sector model therefore generates, in addition to the labour force, the human throughputs for the household formation and the education sector models. The principal source for the data used in the demographic model is Illing *et al.*[1]

2. The Household Sector

In the specification of the demand equations and in the demand projections the basic consumer of the services in question is the household. We therefore extend our demographic model to include the process of household formation. The household, rather than the family, is the relevant variable since we are interested in the effect on demand for telecommunications, not only of the increase in the number of families, but also in the increase of dwelling units resulting from the reduction in shared accommodation.

Marriages are a function of the number of persons in a certain age group in the demographic model (20-34 years). Net immigration is a second source of change in the number of households; and, of course, deaths of married persons or householders constitute an outflow from the stock of households. The growth in the stock of households has exceeded substantially the growth in the stock of families over the past twenty years. Obviously this phenomenon has important implications for the demand for telecommunications services and it is therefore taken into account in this study. The figure for total households in year t is

---

[1] Wolfgang M. Illing *et al*, *Population, Family, Household and Labour Force Growth to 1980*, Staff Study No. 19, Economic Council of Canada, Queen's Printer, Ottawa, 1967.

derived from the formula

$$H_t = \frac{h_t}{1-n_t} F_t,$$ where h_t is the ratio of the number of family households to the number of families, and n_t is the ratio of nonfamily to total households.

Details of the calculations summarized here, as well as statistical tables and sources may be found in Illing *et al.*[1]

3. The Education Variable

It is useful for our purposes to think of a stock of knowledge and habits in the population. This stock is fed in large part by the flow through the formal education system. Quantification of this important characteristic is of particular importance to the present study, for the average level of education in the population plays a dual role in the demand for services of the telecommunications industry.

First, the education stock enters the productive process of the economy as an input and thereby affects the demand for services indirectly via its influence on the overall level of economic activity or, more specifically, on the level of per capita income. Secondly, the average level of formal education is hypothesized to exert a direct influence on the demand for telephone and telegraph services under the hypothesis that behaviour patterns *viz a viz* these services vary among persons with different levels of education.

Considerable pains have therefore been taken to measure in an operational way the "stock" of education in the households of Canada. To

---

[1] *Ibid.*

this end an index is constructed. The method of construction is described in some detail.

The first step was to use enrolment projections[1] in conjunction with census benchmark data, to estimate the numbers of persons of working age (but not in school) at each of four education levels: i. primary or less, ii. secondary, iii. some university, and iv. university degree. The formula used was:

$$(2.1) \quad N_t^j = (1-d^j)\, N_{t-1}^j + m_t^j \,,$$

N_t^j: the number of persons in the source population with level of education j in period t,

m_t^j: the inflow to the source population of persons with education level j in period t.

d^j: the drop-out rate for the source population of level j.

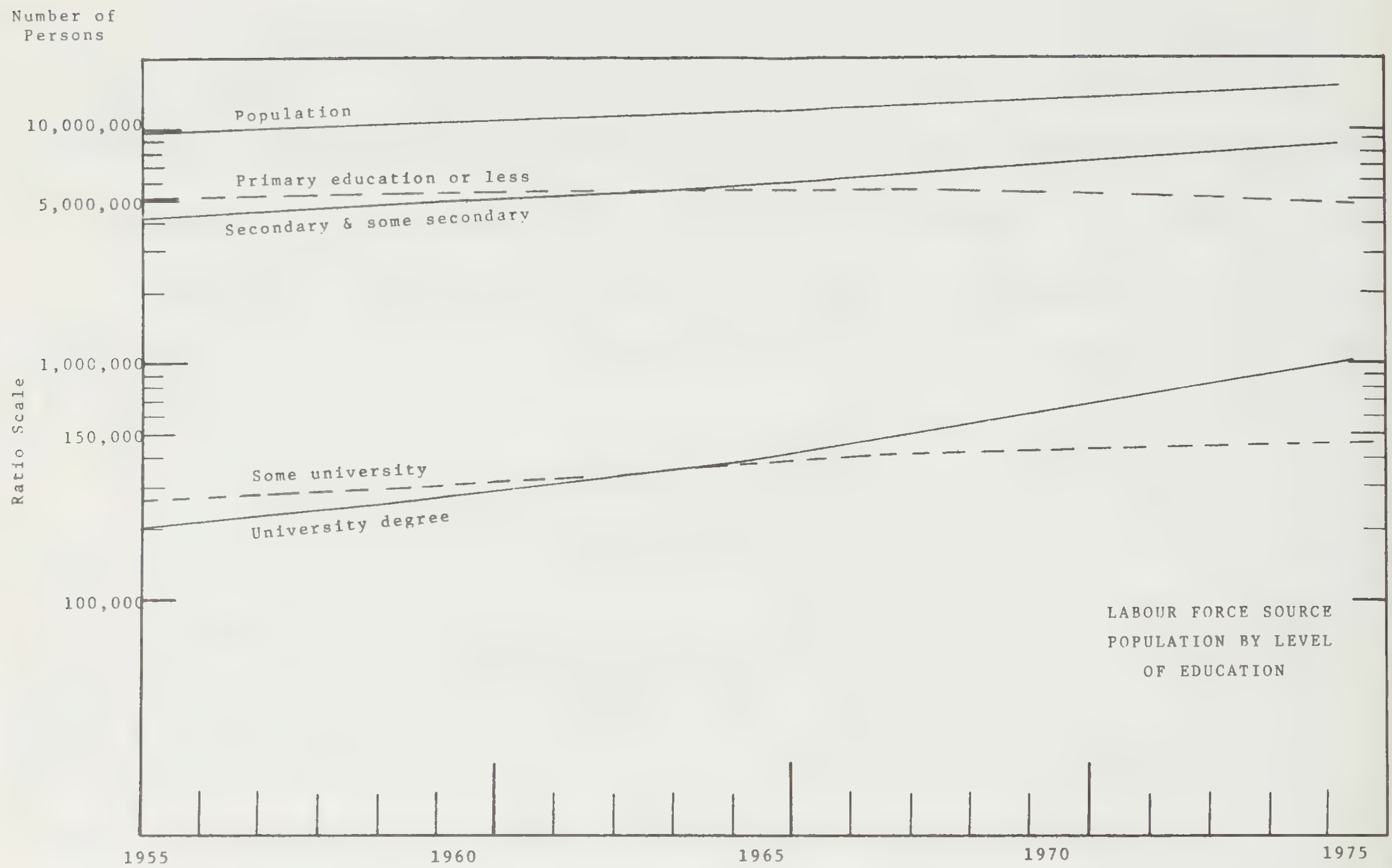
The resulting series are plotted in Figure 2.2 to a semi-logarithmic scale. Here we can observe the joint effect on the labour force source population of the changing pattern of school enrolment and retention rates and of the shifts in the age composition of that population. Using these data an education index was constructed. The formula for this index is

$$(2.2) \quad E'_{ot} = \frac{N_o}{N_t} \; \frac{\sum_j v^j N_t^j}{\sum_j v^j N_o^j}$$

---

[1] W.M. Illing and Z.E. Zsigmond, Enrolment in Schools and Universities 1951-1952 to 1975-76, Staff Study No.20, Economic Council of Canada, Ottawa, 1967. See also Z.E. Zsigmond and C.J. Wenacs, Enrolment in Educational Institutions by Province 1951-52 to 1980-81, Staff Study No.25, Economic Council of Canada, Ottawa, 1970.

FIGURE 2.2


Number of Persons
Ratio Scale
10,000,000
5,000,000
1,000,000
150,000
100,000
Population
Primary education or less
Secondary & some secondary
Some university
University degree
LABOUR FORCE SOURCE POPULATION BY LEVEL OF EDUCATION
1955
1960
1965
1970
1975

which can be rewritten:

$$(2.2a) \quad E'_{ot} = \frac{N_o}{N_t} \sum \frac{v^j N^j_o}{(\sum v^j N^j)} \frac{N^j_t}{N^j_o}, \quad (t=1,\ldots,T)$$

where the newly introduced symbols are:

E'_{ot} : the education level index for year t with base year o (1955),

v^j : the earnings differential for education level j computed according to the Denison 3/5 formula see Appendix 5).

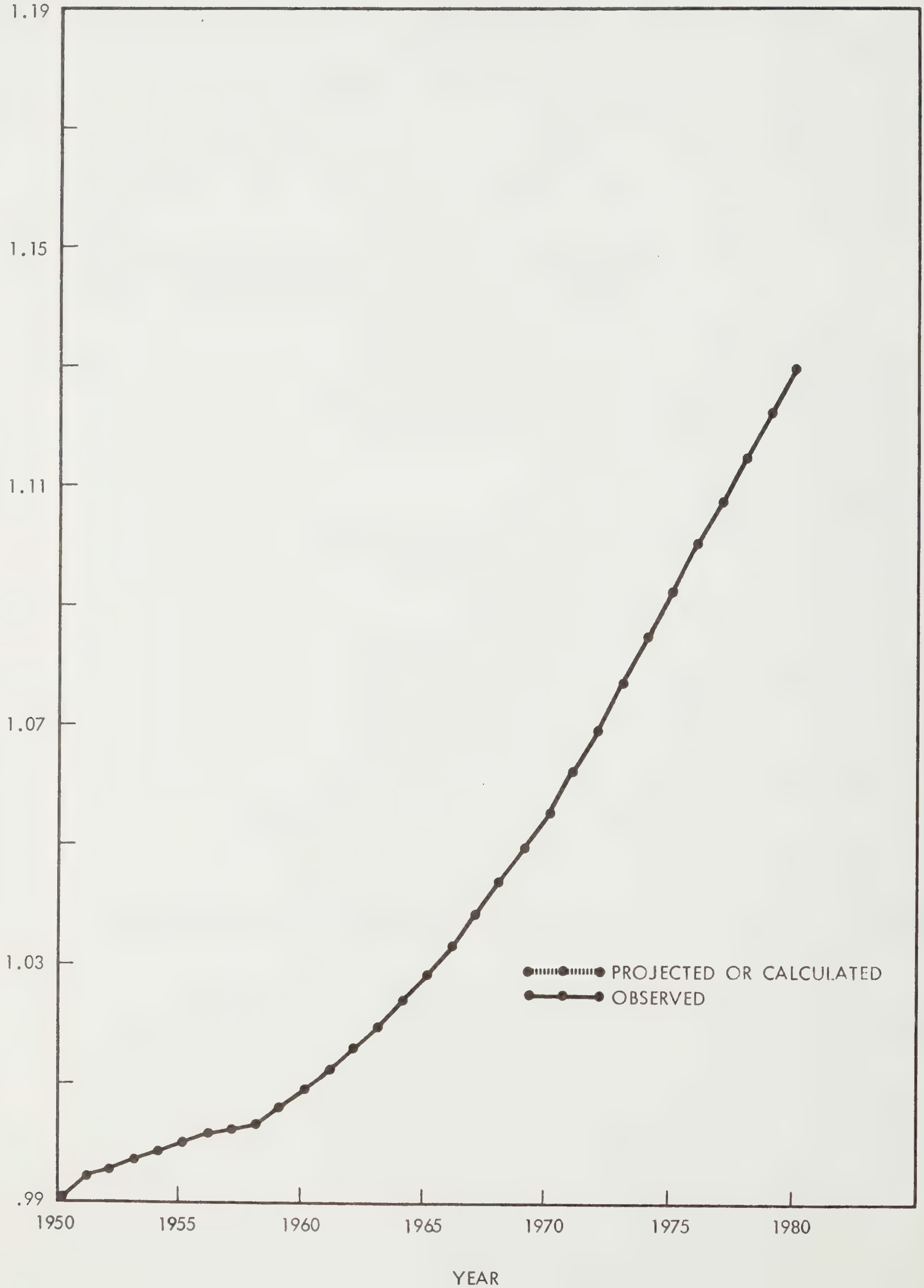
The purpose of rewriting Formula (2.2) in form (2.2a) is to demonstrate that the education level index is a weighted aggregate of individual level relatives where the weights are base period shares of income attributable to education.

The index number calculated in this way is shown graphically in Figure 2.3 and is listed in Appendix Table A.3.

It should be recognized, of course, that the index presented here represents a measure of formal education only. It is well known that the growth of knowledge and skills in the labour force source population takes place to a substantial degree outside the formal apparatus of education. This aspect of education is difficult to quantify. However, the age-sex adjustment to the labour force described in the next section represents an undertaking in this direction.

FIGURE 2.3

EDUCATION INDEX 1950 - 1980



III. The Output Model

1. Introduction

This section describes in summary form the model used to project potential output of the Canadian Economy over the period 1968-1980. The method employed is to specify an aggregate production function. After the parameters of this function have been estimated, it is used in conjunction with the human inputs described in Section II and the non-human inputs described below to generate figures for the potential output of the Economy to 1980. These output figures provide the basis for calculating total consumption expenditures which, in turn, are used in the demand forecasts described in Section IV.

The basic input components of the model are cohort-survival processes which produce stock variables for age-sex adjusted labour, education, and capital. Particular attention is paid to the first two because changes in these over the period of study appear to be larger in Canada than in most other countries. The resulting indexes are the variables used in fitting the production function:

$$Y = A\ 10^{a+dc+eT}\ J_{\lambda}^{\alpha}\ (H\hat{L}^{\log E})^{\beta}.$$

2. The Labour Variable

Changes in the size and composition of the labour force over the period of projection (1965-1980) will be unusually large in Canada. The first column in Table 3.1 provides a comparison between Canada and selected countries of the increase in the size of the labour force. The second column shows Canada's female participation rate in 1962 to have

been the lowest of any of these countries. This participation rate is expected to rise to approximately the United States level by 1975 with a resulting substantial change in sex composition. Equally dramatic, although not shown in Table 3.1, is the anticipated change in age composition resulting from the increased proportional size of the younger age groups.[1] Studies have revealed a consistent pattern of earned income differentials among persons of different ages and between the sexes.[2] These differentials are assumed in this study to reflect age-specific and sex-specific differences in productivity. It is possible that earnings differentials, particularly those between the sexes, reflect non-economic factors. However, it seems likely that these factors, discrimination for instance, take the form of forcing certain of the groups into less productive employment and therefore the use of earnings differentials as indicators of productivity differences is held to be valid.

Under these circumstances the appropriate procedure is to aggregate the age-sex categories of the labour force by use of a Divisia index.[3] This procedure requires income share data for each period (or

---

[1] W. Illing, op. cit., Table 4-6, p. 101. (See Table 2.1).

[2] See for example J.R. Podoluk, Earnings and Education, Dominion Bureau of Statistics Monograph 91-510, Ottawa, 1965.

[3] For recent discussion on the properties and computation of Divisia indexes see: D.W. Jorgenson, "The Embodiment Hypothesis", Journal of Political Economy, Vol. 74, No. 1 (Feb. 1966), pp. 1-17, D.W. Jorgenson and F. Griliches, "The Explanation of Productivity Change", Rev. of Economic Studies, XXXIV (3), No. 99, and M.K. Richter, "Invariance Axioms and Economic Indexes", Econometrica, XXXIV (4), (October 1966).

TABLE 3.1

Labour Force Growth in Selected Countries, 1965-80

	Per Cent Change in Labour Force 1965-80	Females as a Percentage of the Labour Force, 1962
Britain	4.4	33.8
France	13.5	33.3
Germany (F.R.)	5.5	36.4
Italy	1.7	27.8
Sweden	-0.3	31.4
United States	29.5	32.8
CANADA	49.8	27.2

SOURCE: Wolfgang M. Illing *et. al.*, *Population, Family, Household and Labour Force Growth to 1980*, Staff Study No. 19, Economic Council of Canada, Ottawa, 1967, Tables 4-C, 4-H.

at least for a number of periods), and therefore could not be used since income differentials are available in the required detail only for the year 1961. The method used was to construct an index of the age-sex adjusted labour force using base period (1961) income shares as weights. The index used is a geometric,

$$(3.1) \quad L_t = \prod_{i=1}^{12} L_{it}^{w_i} ,$$

where

$$w_i = \frac{p_i L_i \ (1961)}{\sum p_i L_i \ (1961)}$$

and the symbols have the meanings

L_{it} number of persons in age-sex group i in period t as a quantity relative to base 1955.

p_i relative price of age-sex group i in 1961 (Table 3.2, Column 3).

The rate of growth of this index is given by

$$\frac{\dot{L}_t}{L_t} = \sum_i w_i \frac{\dot{L}_{it}}{L_{it}} .$$

The absence of a time subscript for w_i is the difference between this and a Divisia index. Its use therefore incorporates the assumption that income shares of different age-sex groups are constant over the sample period and the period of projection.

<u>The Potential Labour Force</u>

The employed labour force was used in the estimation process.

In order to calculate and project potential output, a potential labour force series was required. The basic data were the total labour force series classified by age and sex supplied by the Dominion Bureau of Statistics. In order to convert these data to a potential man-hours series we applied an adjustment for the unemployment rate consistent with the Economic Council's definition of potential--three per cent. We could have applied a factor of .97 to our total man-hours series to make this adjustment. However, age-sex specific unemployment rates differ widely, and it was felt that this variation should be recognized in the calculations. Accordingly, we estimated age-sex specific unemployment rates consistent with an aggregate unemployment rate of three per cent. These estimates appear in Table 3.2. It is interesting to observe the inverse relationship between these unemployment rates and the productivity weights. This relationship is particularly marked in the case of males. It is also discernible for females. However, in the latter case there appears to be some confounding of participation rates and unemployment rates in the data.

The twelve age-sex groups were then multiplied by their respective "potential" employment rates and the resulting series were aggregated in precisely the same manner (and using the same weights) as that described in equation 3.1 above. The resulting series are used in conjunction with the estimated production function to calculate the potential output projections.

TABLE 3.2

Age-Sex Specific Unemployment Rates[1]
and Productivity Weights

	Age Group	Unemployment Rate	Productivity Weight
Males	15-19	7.2	.42
	20-24	4.6	.65
	25-34	2.8	.89
	35-44	2.4	1.00
	45-54	2.7	.99
	55+	3.0	.92
Females	15-19	4.2	.37
	20-24	2.2	.49
	25-34	1.8	.57
	35-44	1.2	.57
	45-54	1.2	.57
	55+	0.9	.55

[1] For aggregate unemployment rate of three per cent.

The Total Labour Force

This study also makes use of the total labour force as an explicit variable. The sense in which "total" is used here is that no adjustment is made for employment rates either observed or potential. The total labour force was used to form a labour-capital ratio series. The labour-capital ratio was used to obtain projections for the potential capital stock as described below.

Average Weekly Hours

The average of hours worked per week by the employed labour force shows substantial movement over time. This variation was taken into account in an earlier analysis of Canadian potential output[1] and we also convert labour force figures to an effective annual man-hours series.

This was done by constructing an annual index of the historical average hours series and multiplying the index of the age-sex adjusted labour force by this average hours index. For the employed labour force we used a conventional man-hours index. For the potential labour force, however, we followed Drabble's procedure, extracting the trend from the historical man-hours series, expressing the trend in index number form and multiplying our age-sex adjusted potential labour variable by this index.

---

[1] B.J. Drabble, Potential Output 1946 to 1970, Staff Study No. 2, Economic Council of Canada, Ottawa, 1964.

3. Education

The education variables described in the preceding section have, as was noted, a dual role in this study. First, they enter the productive process of the economy as an input and secondly the education variables have a direct effect on the demand for telecommunications services. In this section we are concerned with the first of these effects--the output effect.

The average level of education attainment of the labour force is, of course, a qualitative attribute in much the same sense that the age distribution is. Indeed, the adjustment for age composition described in the preceding section represents an attempt to capture the important part of education which takes place outside the apparatus of the education system.

It was decided to treat formal education as a separate input variable. This procedure evolved in part from earlier research on the role of education in Canadian economic growth[1], and was dictated in part by the particular production function employed. In order to use this approach, it was necessary to have available a single indicator of the "quantity" of formal education. The education indicator used is the index described in Section II.

---

[1] Gordon W. Bertram, The Contribution of Education to Economic Growth, Staff Study No. 12, Economic Council of Canada, Ottawa, 1966.

4. Capital

Considerable attention has been paid to the quantity and to the qualitative attributes of the human inputs in the production process. It is equally desirable to make a precise measurement of the non-human factors of production. Here difficulties of measurement are even more acute than those encountered in the area of human resources. For example, we should obviously like to measure separately the productive services of land and other natural resources on the one hand and reproducible non-human factors of production (capital) on the other. From the outset we had to forego use of an explicit "land" input. The data for this variable are not presently available. Our non-human factor input is therefore limited to reproducible capital goods. A further difficulty arises in connection with this capital variable. We would have preferred to develop a variable representing the services of capital.[1] However, we were not able to do this but had to use

---

[1] For a compelling argument see D.W. Jorgenson and F. Griliches, "The Explanation of Productivity Change", Rev. of Economic Studies XXXIV (3), No. 99.

the net stock of capital as a proxy for the flow of services.

The procedure employed was to divide capital goods into two categories, construction and machinery and equipment. Then, using historical gross investment figures for the two broad classes of capital assets in conjunction with their average lives, we constructed net capital stock series for each. Addition of the two series yields a single aggregate figure for the net capital stock. This technique has the disadvantage that it confers the same weight on a unit of capital produced today as on a surviving unit produced a dozen years ago. There is evidence that a part of technological advance is embodied in new capital. We have taken considerable pains to measure the equivalent quality changes in human resources and it would be desirable to apply a similar analysis to physical capital.

The apparatus adopted for this purpose is that of Solow[1]. It is general in the sense that it enables ready computation of a "conventional" net capital stock series or alternatively an "equivalent" capital stock series (or set of such series) incorporating embodied technological change.

---

[1] R.M. Solow, "Technical Progress, Capital Formation, and Economic Growth", American Economic Review, Papers and Proceedings, May, 1962, p. 76. The Solow approach to capital measurement was also applied by M.D. Intriligator, "Embodied Technical Change and Productivity in the United States 1929-58", Review of Economics and Statistics, February, 1965, p. 65. It was again used together with Denison's labour series in a study of United States potential output to 1970 by L.C. Thurow and L.D. Taylor, "The Interaction between Actual and Potential Rates of Growth", Review of Economics and Statistics, November, 1966, p. 351.

The principal results reported in this paper are derived from a variant in which technological change is disembodied with respect to capital.

However, extensive experimentation was carried out with the embodiment hypothesis and some of these results are reported as well. Therefore, the more general formula for deriving the capital stock is discussed here. Solow's notation is used with some additions and modifications.

The capital stock is defined by the formula:

$$(3.2) \quad J_{\lambda}(t) = \sum_{v=-\infty}^{t} (1+\lambda)^{v} (1+\rho)^{-(t-v)} I(v),$$

Where the symbols used are;

$J(t)$ the capital stock in year t

$I(v)$ gross investment in year v

λ a capital "improvement" rate

ρ a depreciation rate.

The first term in the right-hand sum represents the technological improvement effect. Of course, if λ is set equal to zero this term has the value 1 for all values of v, and the resulting capital stock series ($J_o(t)$) incorporates no embodied technological change. Where results using values of λ other than zero are reported, the values for λ appear as two subscripts; the first is the value for the machinery and equipment component, the second the value for structures.

The depreciation rate ρ is derived from average life estimated for the two capital categories.[1] These average life estimates are fifty

---

[1] Dominion Bureau of Statistics, Fixed Capital Flows and Stocks, Manufacturing, Canada, 1926-1960, Ottawa, Queen's Printer, 1967.

years for buildings and construction and twenty years for machinery and equipment.[1] The method for converting an average life estimate to a reducing balance depreciation rate is described by Rymes.[2] The steps in this procedure are:

(1) Compute the "straight line" depreciation rate as the reciprocal of the average life.

i.e., Construction: .025

Machinery and Equipment: .067

(2) Convert these figures to a declining balance rate by multiplication by 2.

i.e., Construction: .050

Machinery and Equipment: .133

(3) The rate so derived is appropriate to the form

$$I(1-\rho')^{L} = S$$

Where I is the cost of the capital good, L its length of service life, S its scrap value, and ρ' the "reducing balance" depreciation rate.

A transformation is required in order to use the reducing balance rate in the form in which it appears in equation 3.2 To obtain the value of ρ in terms of ρ', the following expression is solved for ρ:

$$(1+\rho)^{-1} = (1-\rho'),$$

---

[1] Manufacturing, Catalogue No. 13-522, pp. 87-113. See Appendix 6 for the derivation of these two estimates.

[2] Op. Cit., p. 88.

to yield

$$\rho = \frac{1}{1-\rho'} -1.$$

i.e., Construction: .0523

Machinery and Equipment: .1539

A refinement in specification was incorporated in equation (3.2) to take account of the fact that additions to the capital stock (investment) spread over a one year period are not all in service throughout the period. The assumption employed is that investment is distributed evenly over the year and that therefore, on average, one half of the year's investment is in service for the whole year.

This leads to the following modification of (3.2):

$$(3.3) \quad J_{\lambda}(t) = \sum_{v=-\infty}^{t-1} (1+\lambda)^{v} (1+\rho)^{-(t-v)} I(v) + (1+\lambda)^{t} \frac{I(t)}{2}$$

Lagging (3.3) one period, multiplying both sides by $(1+\rho)^{-1}$, subtracting the resulting expression from (3.3), and rearranging terms produces the formula:

$$(3.4) \quad J\ (t) = (1+\lambda)^{t} \frac{I(t)}{2} + (1+\rho)^{-1} \ \{(1+\lambda)^{t-1} \ \frac{I(t-1)}{2} + J(t-1)\}\ ,$$

which is more convenient for purposes of computation.

Using (3.4) and the values for ρ, λ discussed above, separate net capital stock series were constructed for machinery and equipment and for plant and construction. The series for λ=0 (the net capital stock without adjustment for technical change) are shown in Table A.5 in 1949

dollars. The gross investment data from which the stock series are calculated are also shown in Table A.5.

Capital Stock Projections

The discussion above outlines the concept of capital employed in this study and describes the steps in calculating the series used in the regressions. In order to make potential output projections, it is necessary to have projections of the capital stock. One would, of course, like to have an investment equation or a set of such equations to provide these projections. However, at the current stage of the project behavioural investment equations were not available. The alternative approach employed was to fit a linear trend to the labour-capital ratio. This trend was then extrapolated over the projection period and a potential capital stock to 1980 was derived in this way.

The relevant capital stock concept is a total (rather than an employed) capital stock concept. We therefore formed the capital-labour ratio using a parallel concept of labour--the total labour force. The total labour force as used here is described in Section II.

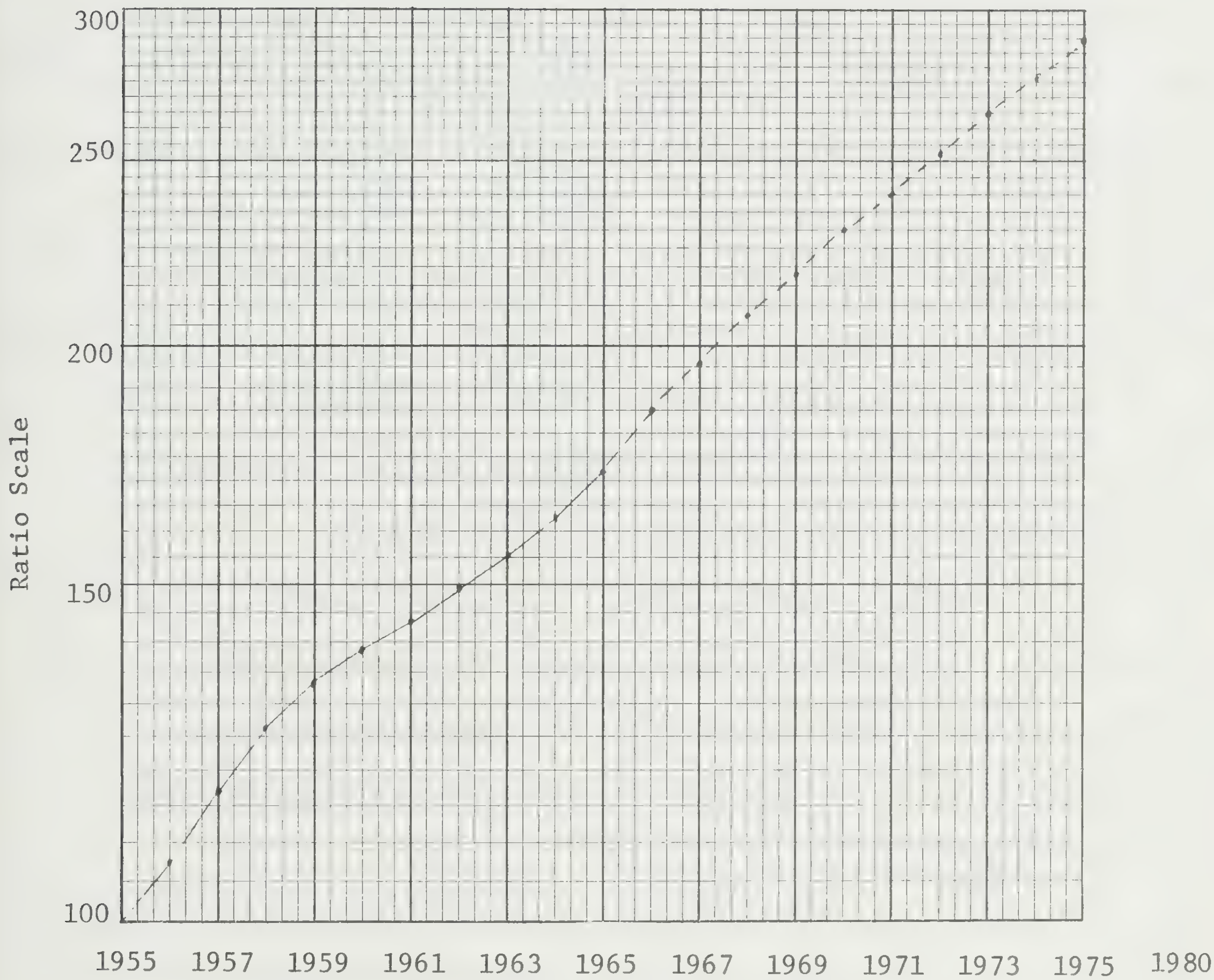
The sample period used in fitting the trends was 1957-65. The shorter period was selected in order to avoid incorporating into the projections the distortions prevailing in the capital stock in the earlier period.

The net capital stock series computed along the lines described above is plotted in index number form in Figure 3-1. The broken portion of the line represents the projected series.

FIGURE 3-1

INDEX OF NET

CAPITAL STOCK



5. The Production Function

The data developed in the preceding sections were used in fitting the production function

$$(3.5) \quad V = A\,10^{\,b+dc+eT}\, J_{\lambda}^{\alpha}\, (H\hat{L}^{\frac{1}{2}\log E})^{\beta},$$

where the symbols are as previously described. This function comes by its hybrid nature from a number of sources. The first is the emphasis of the study which lay in the direction of measuring the effect of labour force quality attributes on the growth of output. This led to a more detailed breakdown of the human inputs. At the same time the greater heterogeneity of non-human inputs and the lack of data on, for example, relative shares of different categories of capital prevented a symetrical treatment of capital. It was felt desirable, however, to recognize explicitly that component of technological change which is embodied in new capital. Hence the technique of Solow, described above was used.

The education variable appears in the form suggested by Hildebrand and Liu.[1] Although evidence is scarce that formal education enters the picture in this particular way, the hypothesis that the output elasticity of labour is functionally related to education seemed worth further investigation.

The term in parentheses on the right hand side of (3.5) may be thought of as labour adjusted for hours worked, age-sex composition and

---

[1] G.H. Hildebrand and T.C. Liu, Manufacturing Production Functions in the United States, 1957, 1965, Ithaca, New York State School of Industrial and Labour Relations, 1965.

TABLE 3.3

Production Function Parameter Estimates†

A	b	d	e	α	$\bar{R}^2$	D.W.*	Potential Output Index (1955=100)
.895	.0181	-.6030 (-3.9364)	.0052 (3.8031)	.3215 (4.3180)	.9901	2.0476	259.34
.888	.0147	-.4894 (-3.3506)	.0054 (3.7893)	.2250 (4.0270)	.9894	2.0567	265.03
.891	.0139	-.4629 (-3.1972)	.0052 (3.4933)	.2056 (3.9546)	.9892	2.0551	270.32
.909	.0161	-.5354 (-3.5931)	.0044 (2.7294)	.2485 (4.1331)	.9896	2.0723	271.34
.907	.0151	-.5029 (-3.4209)	.0045 (2.7352)	.2255 (4.0531)	.9894	2.0705	275.77

t statistics in parentheses

† Using estimating equation

$$\log (V/\tilde{L}) = \log A + b + dc + et + \alpha \log (J_\lambda/\tilde{L})$$

$$\tilde{L} = HL^{\hat{}\frac{1}{2}\log E}$$

* Durbin-Watson Statistic.

education attainment. The parameter β is therefore the output elasticity of labour with embodied technological change. However, substitution of equation (3.3) into (3.5) produces

$$(3.6) \quad V = A\, 10^{b+dc+eT}\, J_\lambda^{\alpha} \left[H \prod_{1}^{12} L_i^{\frac{w_i \log E}{2}} \right]^{\beta},$$

providing individual elasticities for each of the twelve age-sex categories.

Logarithmic differentiation of (3.6) yields the growth rate of output and its components:*

$$(3.7) \quad \frac{\dot{V}}{V} = d\dot{c} + e\dot{T} + \alpha\frac{\dot{J}}{J} + \beta\frac{\dot{H}}{H} + \sum_{i=1}^{12} \frac{\beta w_i \log E}{2} \frac{\dot{L}_i}{L_i} + \frac{\beta}{2} \log\hat{L}\, \frac{\dot{E}}{E}\, .$$

The production function was estimated in logarithmic form using ordinary least-squares. Some of the results appear in Table 3.3. The problem of selecting a "preferred" specification with respect to the values for λ, the capital improvement factor, is a difficult one. As has been the experience in other similar applications,[1] the coefficient of variation doesn't distinguish sharply among the alternatives. At the same time, it can be seen by reference to the last column of the Table, that the alternatives do have a measurable effect on the potential output projections.

We have one year--1966--which is outside the sample period and which can therefore be used in a limited test of the predictive accuracy of the alternative specifications. The results of this test are shown in

---

[1] For example, Solow, op. cit., L.C. Thurow and L.D. Taylor, "The Interaction between the Actual and the Potential Rates of Growth", The Review of Economics and Statistics, XLVIII (4) (November) 1966.

*After transforming certain of the coefficients to take account of the fact that logarithms to base 10 were used.

Table 3.4.

TABLE 3.4

Output Forecasts--1966

Total Economy

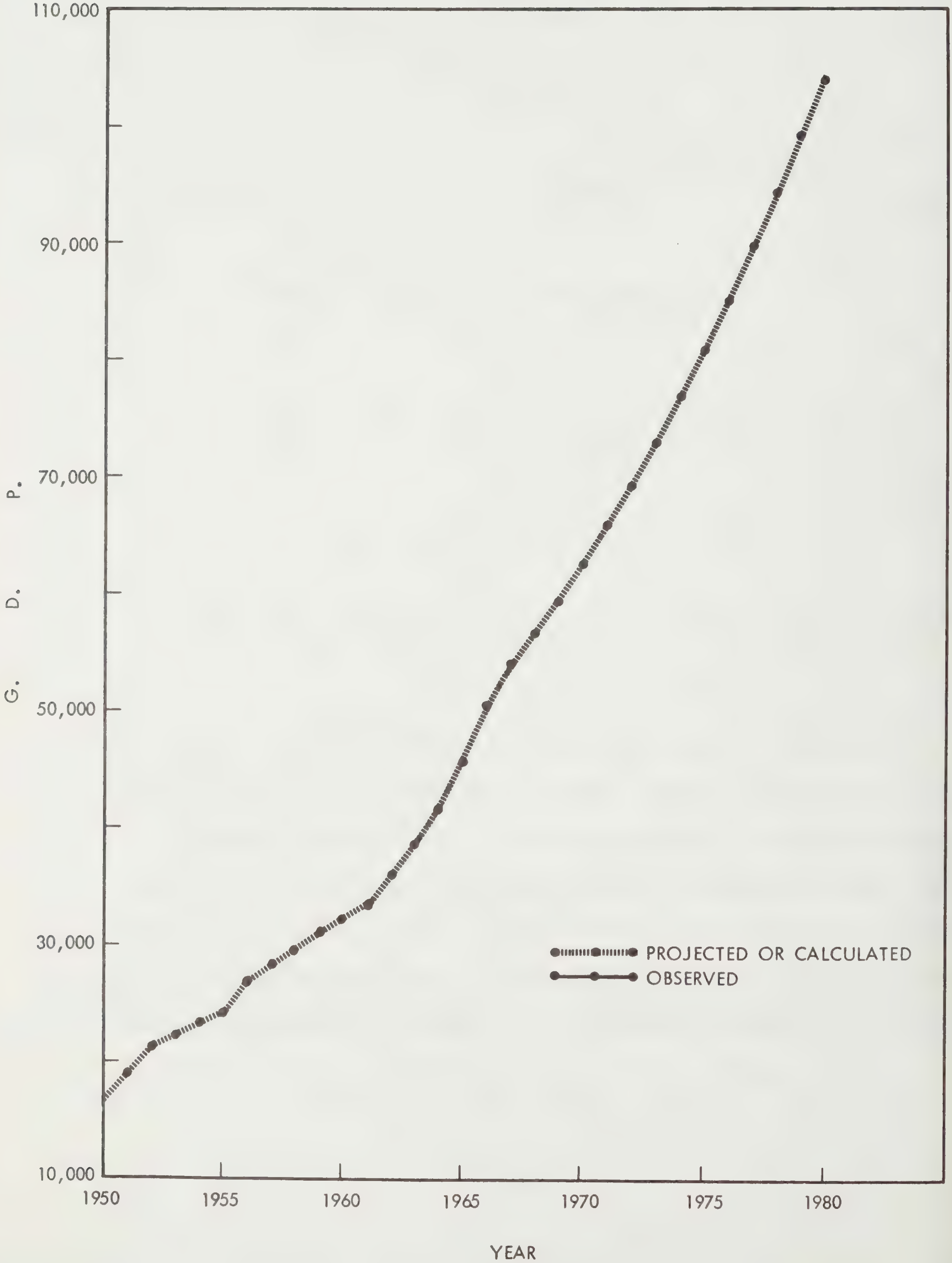
Capital Stock	GDP Forecast 1966(1)	Per cent of Observed GDP (32,856.19)*
J_o	32,585.12	99.17
J_{30}	32,492.97	98.89
J_{40}	32,497.53	98.91
J_{31}	32,521.11	98.98
J_{41}	32,531.25	99.01

(1) In millions of constant 1949 dollars corrected for agricultural yield fluctuation.

It will be noted that the error of forecast is of the order of one per cent in all cases. Again, a clear distinction in favour of any specification for J_λ does not emerge. We therefore selected as the "preferred" function, the specification incorporating J_o. The further results and implications reported below are the results for that particular version. They pertain therefore to a model for which technological change is disembodied with respect to capital but embodied with respect to labour,

FIGURE 3.3

GROSS DOMESTIC PRODUCT AT FACTOR PRICES BY YEAR 1950-1980
(millions of 1949 dollars)



Also used for purposes of this study is the assumption of constant returns to scale. These two characteristics of the output model tend to create a downward bias in the projected growth rates of potential output. However, since there has been a chronic shortfall of actual over potential (see Table 3.5) output over the past seven years, the downward bias may not pose a serious problem. The resulting GDP series are shown graphically in Figure 3.3 and in detail in Appendix Table A.2.

A justification for the considerable detail devoted to the development of these data is illustrated by the pattern of annual growth rates shown in the centre column of Table A.2. It can be seen that the growth rate of GDP accelerates until 1974, then levels off and declines moderately from 1976 to 1980. Needless to state, this type of curvature has an important bearing on the configuration of demand for telecommunications services. We will have occasion to recall it in discussing the demand projections.

TABLE 3.5

Actual as Per Cent of Potential Output

Year	Unemployment Rate	Actual as Per Cent of Potential Output
1958	7.0	91.9
1959	6.0	93.9
1960	7.0	91.9
1961	7.1	91.7
1962	5.9	94.1
1963	5.5	94.9
1964	4.7	96.4
1965	3.9	98.1
1966	3.6	98.8

IV. THE TELECOMMUNICATIONS SECTOR

The Demand Model for Telephone Service

The preceding sections have built up in some detail a set of variables which are of direct relevance to the problem of forecasting the course of demand for telecommunications services in Canada. We now turn to a description of the process by which these predictors were combined with the historical data on industry revenues in developing the forecasts reported in this section.

It will be recalled that the principal goal of the study is the projection of household requirements for telecommunications to 1980. Additional research goals are the analysis of demographic effects, the measurement of income and possibly price elasticities and development of some estimate of the impact of changing habit patterns with respect to these communications services.

Ideally, one would like to make the projections in terms of a uniform and preferably technical unit of measurement such as 100-mile 3-minute equivalent toll calls or a message-minute-miles unit. A search of available data, however, reveals that this approach can not be used. As an alternative, projections have been developed in constant (1967) dollar industry revenues for two classes of service--local and toll, and, of course, for their sum as well.[1]

There were two reasons for separating local from toll revenues. First, the two are essentially different commodities and consequently the behavioural parameters governing them may be expected to differ

---

[1] For a discussion of the deflaters employed see Appendix Table A.4.

substantially. Secondly, the policy implications of the forecasts are not independent of diverse growth rates for the two classes of trade. For example, the relative future emphasis given to installation of switching and trunking facilities in Canada may be seen to depend on future demand configurations in the two areas.

There are a number of different demand models which can be used in studies of the present type. The model adopted in this study is that of Houthakker and Taylor.[1] The principal reason for the selection was a characteristic of the approach which permits measurement and analysis of changing habit patterns.

The model is developed by Houthakker and Taylor along the following lines:

Assume initially that the demand for a good, say, telephone service, in time period t is determined by the incomes of the consumers of the service and by a "state variable" which, in the case of telephone service, represents habit patterns of consumers with respect to the use of the telephone. This hypothesis can be stated algebraically as follows:

$$q_t = d + \beta s_t + \gamma x_t \tag{4.1}$$

where q_t = purchases of telephone calls in constant (1967) dollars per household of Canadian population during time interval from t to t + 1.

s_t = habit patterns of the average consumer or a psychological "stock of habits" prevailing during the interval expressed in constant dollars per household.

---

[1] H.S. Houthakker and L.D. Taylor, Consumer Demand in the United States, 1929-70, Cambridge, Harvard University Press, 1966. For a Canadian application see T.T. Schweitzer, Personal Consumption Expenditures in Canada, 1926-75, Part I, Ottawa, Queen's Printer, 1969.

x_t = "Normal" or "permanent" disposable income in constant dollars per household, during the interval.

The variable s_t is not directly observable. However, it can be eliminated in the following manner:

(4.2) $\Delta s_t = q_t - w_t$

where Δs_t = change in stock of habits of consumers <u>during</u> the time period t.

w_t = wasting or "depreciation" of this stock during the same time interval.

Assume further

(4.3) $w_t = \delta s_t$

where δ is a constant "depreciation" rate.

Substitute (3) into (2) to obtain

(4.4) $\Delta s_t = q_t - \delta s_t$

Next use (1) to eliminate s_t from (4)

(4.5) $\Delta s_t = (1-\frac{\delta}{\beta})\ q_t + \frac{\alpha\delta}{\beta} + \frac{\gamma\delta}{\beta}\ x_t$

Write (1) in first difference form

(4.6 $q_t - q_{t-1} = \beta(s_t - s_{t-1}) + \gamma(x_t - x_{t-1})$.

Now assume that $s_t - s_{t-1}$ can be approximated in the following manner:

(4.7) $s_t - s_{t-1} \simeq \frac{1}{2}(\Delta s_t + \Delta s_{t-1})$

which holds true if the behaviour of the s variable is linear within each time period. Then

$$(4.8)\ q_t - q_{t-1} = \frac{\beta}{2}(\Delta s_t + \Delta s_{t-1}) + \gamma(x_t - x_{t-1})$$

Substituting (5) into (8) we obtain

$$(4.9)\ q_t - q_{t-1} = \frac{\beta}{2}\ (1-\frac{\delta}{\beta})\ q_t + \frac{\alpha\delta}{\beta} + \frac{\gamma\delta}{\beta}\ x_t + (1-\frac{\delta}{\beta})q_{t-1} +$$

$$\frac{\alpha\delta}{\beta} + \frac{\gamma\delta}{\beta}\ x_{t-1}\ + \gamma(x_t - x_{t-1})$$

This can be simplified (provided $\overline{\beta-\delta} \neq 2$) to

$$(4.10)\ q_t = \frac{\alpha\delta}{1-\frac{1}{2}(\beta-\delta)} + \frac{1+\frac{1}{2}(\beta-\delta)}{1-\frac{1}{2}(\beta-\delta)} + \frac{\gamma(1+\frac{1}{2}\delta)}{1-\frac{1}{2}(\beta-\delta)}x_t$$

$$- \frac{\gamma(1-\frac{1}{2}\delta)}{1-\frac{1}{2}(\beta-\delta)}x_{t-1}$$

s_t has disappeared from the equation and the remaining variables are now the directly observable quantities q_{t-1}, x_t and x_{t-1}.

For computational reasons it is convenient to express

$$(4.11)\ x_t = x_{t-1} + (x_t - x_{t-1})$$

which leads to

$$(4.12)\ q_t = \frac{\alpha\delta}{1-\frac{1}{2}(\beta-\delta)} + \frac{1+\frac{1}{2}(\beta-\delta)}{1-\frac{1}{2}(\beta-\delta)}\ q_{t-1} + \frac{\gamma\delta}{1-\frac{1}{2}(\beta-\delta)}\ x_{t-1}$$

$$+ \frac{\gamma(1+\frac{1}{2}\delta)}{1-\frac{1}{2}(\beta-\delta)}\ (x_t - x_{t-1})$$

or simply

$$(4.12a)\ q_t = A_0 + A_1 q_{t-1} + A_2 x_{t-1} + A_3 \Delta x_t$$

Here Δx_t stands for the difference in x <u>between</u> the two time periods t and t-1. The parameters α,β,γ and δ of equation (1) and (3) can be obtained from the coefficients of (12a)

$$(4.13)\ \alpha = \frac{2A_0(A_3-\frac{1}{2}A_2)}{A_2(A_1+1)}$$

$$(4.14)\quad \beta = \frac{2(A_1-1)}{A_1+1} + \frac{A_2}{A_3-\frac{1}{2}A_2}$$

$$(4.15)\quad \gamma = \frac{2(A_3-\frac{1}{2}A_2)}{A_1+1}$$

$$(4.16)\quad \delta = \frac{A_2}{A_3-\frac{1}{2}A_2}$$

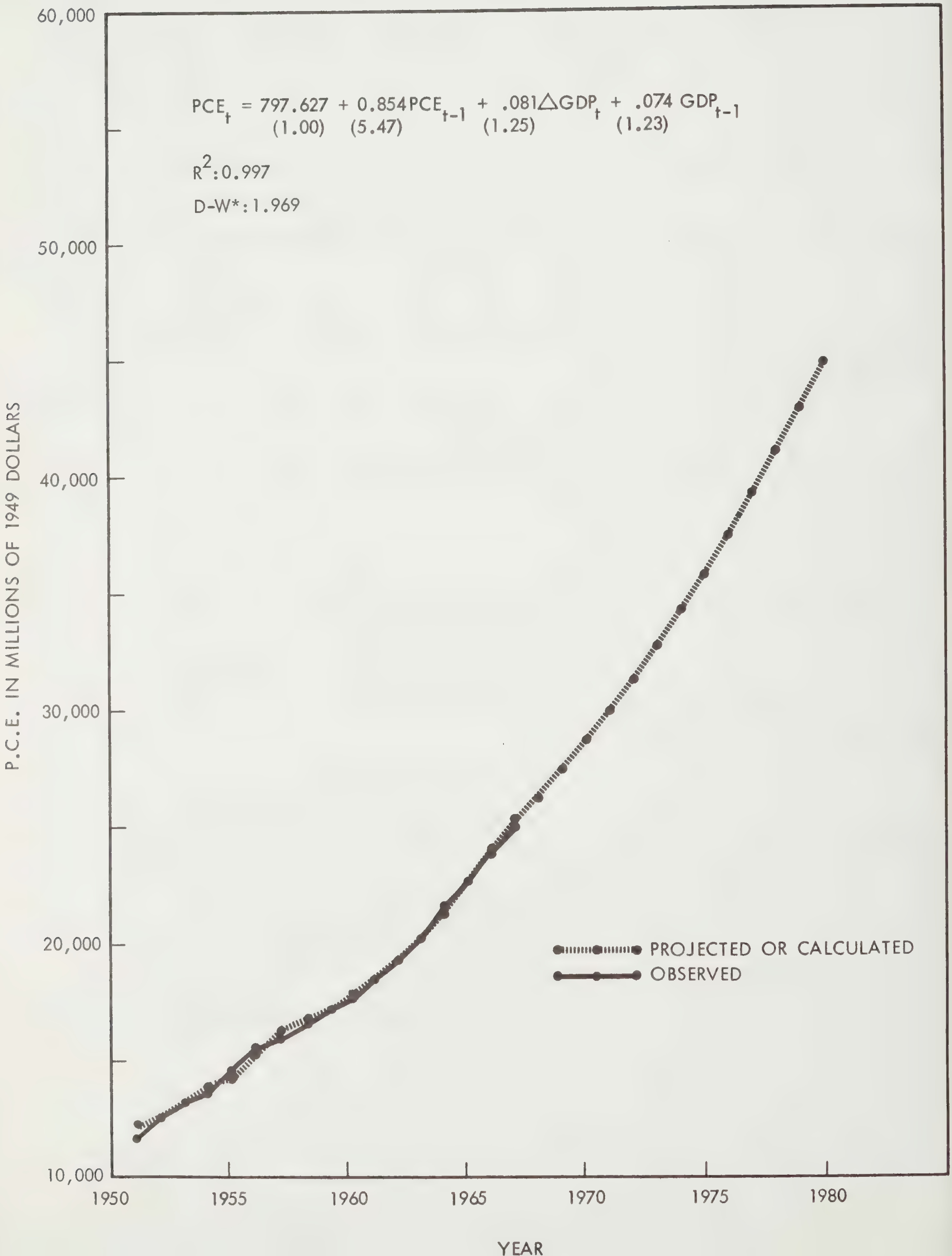
Equation (4.12a) is the basic demand equation used in this study. The first use to which it was put was the derivation of the series x_t for the forecast period. This series is the "permanent income" series and is approximated here by per household expenditure on consumption.

The procedure was to treat personal consumption expenditure (P.C.E) as the dependent variable and gross domestic product (G.D.P) and lagged PCE as regressors for the sample period 1950-1967. The estimator used was ordinary least-squares. The resulting equation was then used in conjunction with the GDP projections developed in Section III, to forecast total personal consumption expenditure in 1949 dollars from 1968 to 1980. The results are shown graphically in Figure 4.1 and numerically in Appendix Table A.2.

Having developed the projections for personal consumption expenditure in the aggregate, it is now possible to analyse and project the component of PCE accruing to the telephone industry. The procedure was again to fit equation (4.12a). This was done (a) with revenue from local service as the dependent variable, (b) with revenues from toll service as the dependent variable and (c) with the combined revenues

FIGURE 4.1

TOTAL PERSONAL CONSUMPTION EXPENDITURE 1950 - 1980



from both types of service as the dependent variable.

In all cases the variables were placed on a per household basis by dividing each by the relevant household figures developed in Section II.

There are reported, however, two further variations on this theme.

(1) The education index was inserted in the demand equation under the hypothesis stated in Sections I and II that the demand for telephone service is related to the level of education or to some social variable for which the education index is a surrogate.[1]

(2) A price variable was introduced in an attempt to measure the price elasticity of the two types of service.

The results of these regressions are summarized in Table 4.1. Interpretation of the coefficients α, β, γ, δ is discussed in detail in Houthakker and Taylor.[2] A brief summary relevant to the special case of telephone service will suffice here. It will be recalled that the variable s_t is a "state" variable representing a psychological stock of habits with respect to the telephone possessed by the average consumer. Its coefficient, β, would therefore, in the present situation, be expected to be positive. This turns out to be the case in all six of the specifications shown in Table 4.1.

The coefficient γ represents the short-range effect of a unit change in x on q. Short range in this context means one calendar

---

[1]Informal discussions with industry officials provided subjective support for this hypothesis.

[2]Ibid.

TABLE 4.1

Parameter Estimates for

Local and Toll Revenues under Alternative Specifications *

	α	β	δ	γ	$\bar{R}^2$	D-W
Local Service						
Standard specification	-3.753	1.056	1.134	0.001	.999	1.260
Education variable included	-2.169	1.714	1.748	0.001	.999	1.223
Toll Service						
Standard specification	-8.543	0.766	1.086	0.003	.997	2.423
Education variable included	-20.864	0.563	.898	0.002	.997	2.345
Combined Local and Toll Service						
Standard specification	-8.556	2.159	2.301	0.003	.999	2.399
Education variable included	-4.651	3.502	3.631	0.002	.999	2.277

* The price variant equation is shown in Figures 4.8 - 4.10.

year. Clearly, this coefficient should have a positive sign which again it does in all cases.

The coefficient δ is the "declining balance" depreciation rate for the stock of habits of the telephone user. In the present application this interpretation seems somewhat forced. However, the coefficient would be expected to be positive here, which it is in all cases. It is also relatively large, indicating that behaviour patterns with respect to telephone use are changing rapidly.

V. The Projections for Telephone Service

Turning now to the forecasts, we have the problem of assessing the effects of the alternative specifications and of selecting a "preferred" forecast. In order to provide a convenient basis for comparison, the alternative specifications are shown pair-wise in Figures 4.2 to 4.10. Each figure shows the estimated equation, the t-statistic for each coefficient, the multiple correlation coefficient ($\bar{R}^2$), and the Durbin-Watson statistic (D-W) for testing the serial independence of the residuals. The graphs show the observed values for the sample period, the values calculated from the regression equation for the sample period and the values calculated from the regression equation for the period of projection. The vertical scales represent per household expenditures on telephone service in 1967 dollars. In all cases, the fit of the equation to the data as measured by the $\bar{R}^2$ statistic is extremely good. By this criterion the addition of the education adjustment and the price variable has no significant "explanatory" value. These two modifications do, however, affect the

FIGURE 4.2

LOCAL REVENUES PER HOUSEHOLD

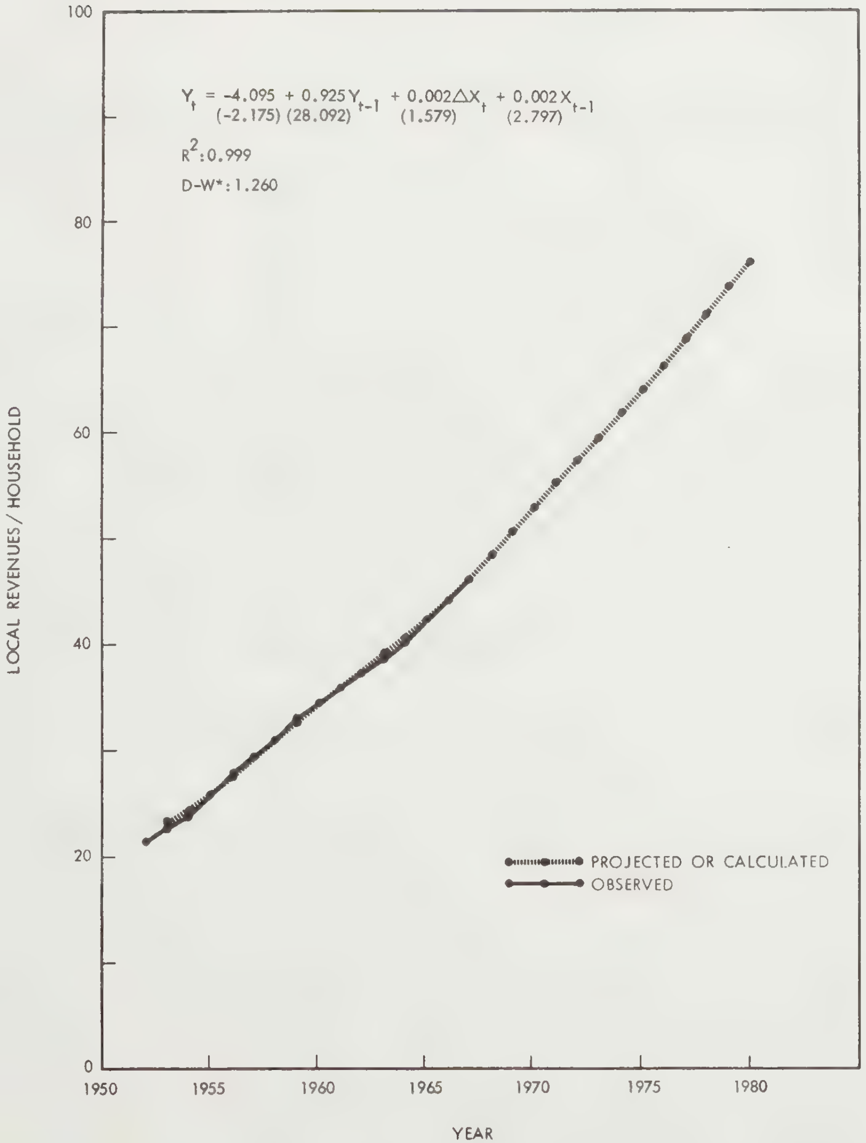


FIGURE 4.3

LOCAL REVENUES PER HOUSEHOLD ADJUSTED BY EDUCATION

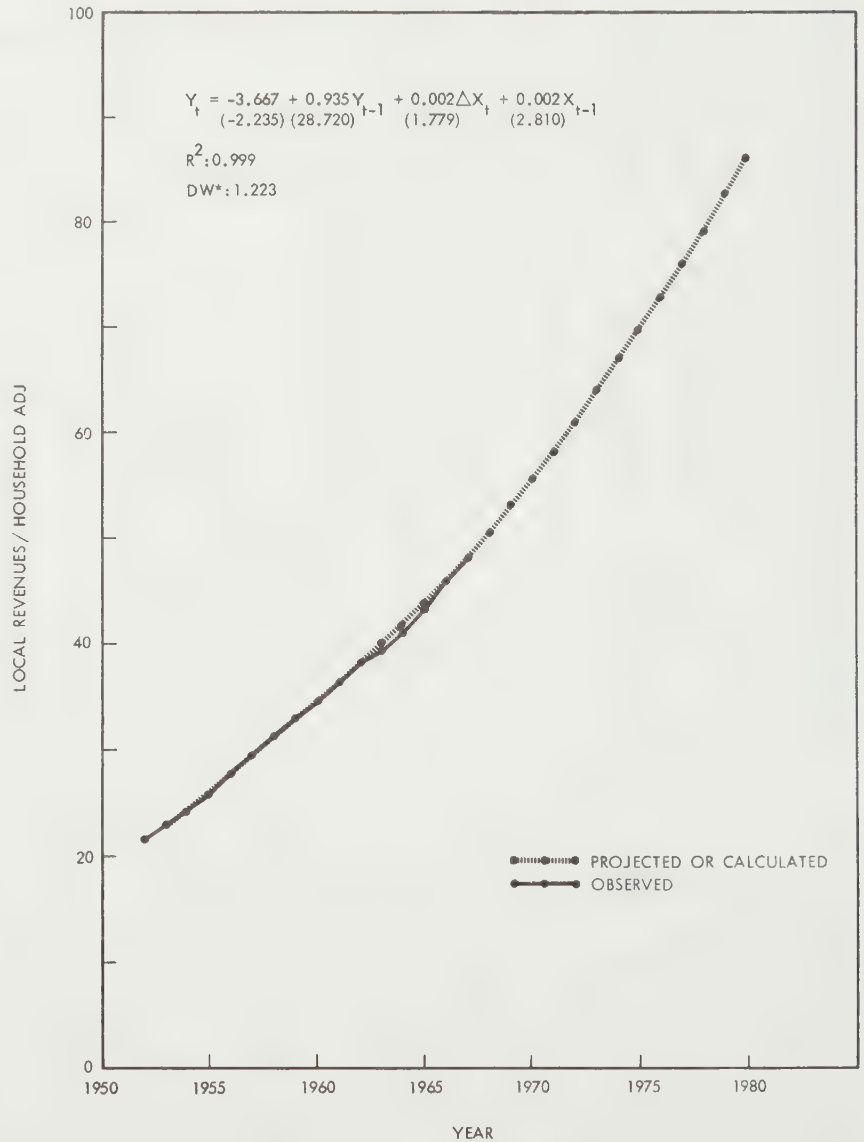


FIGURE 4.4

TOLL REVENUES PER HOUSEHOLD

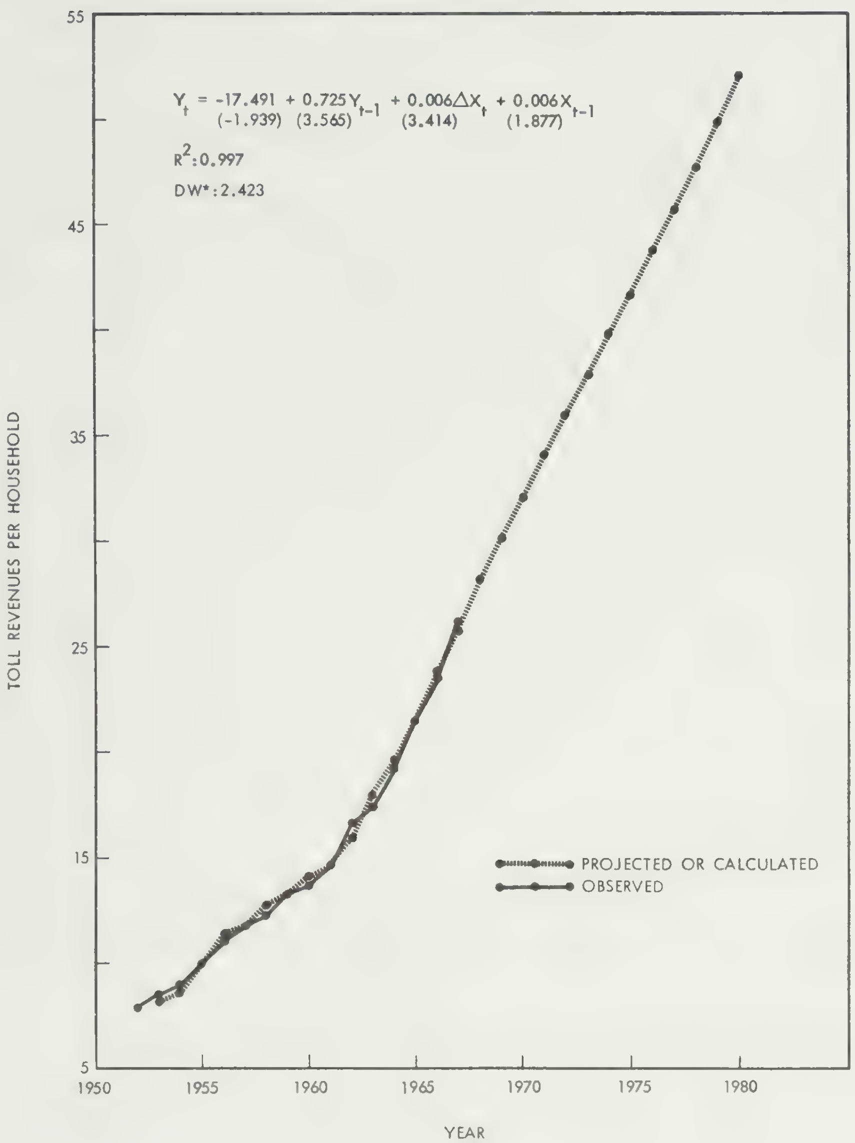


FIGURE 4.5

TOLL REVENUES PER HOUSEHOLD ADJUSTED BY EDUCATION

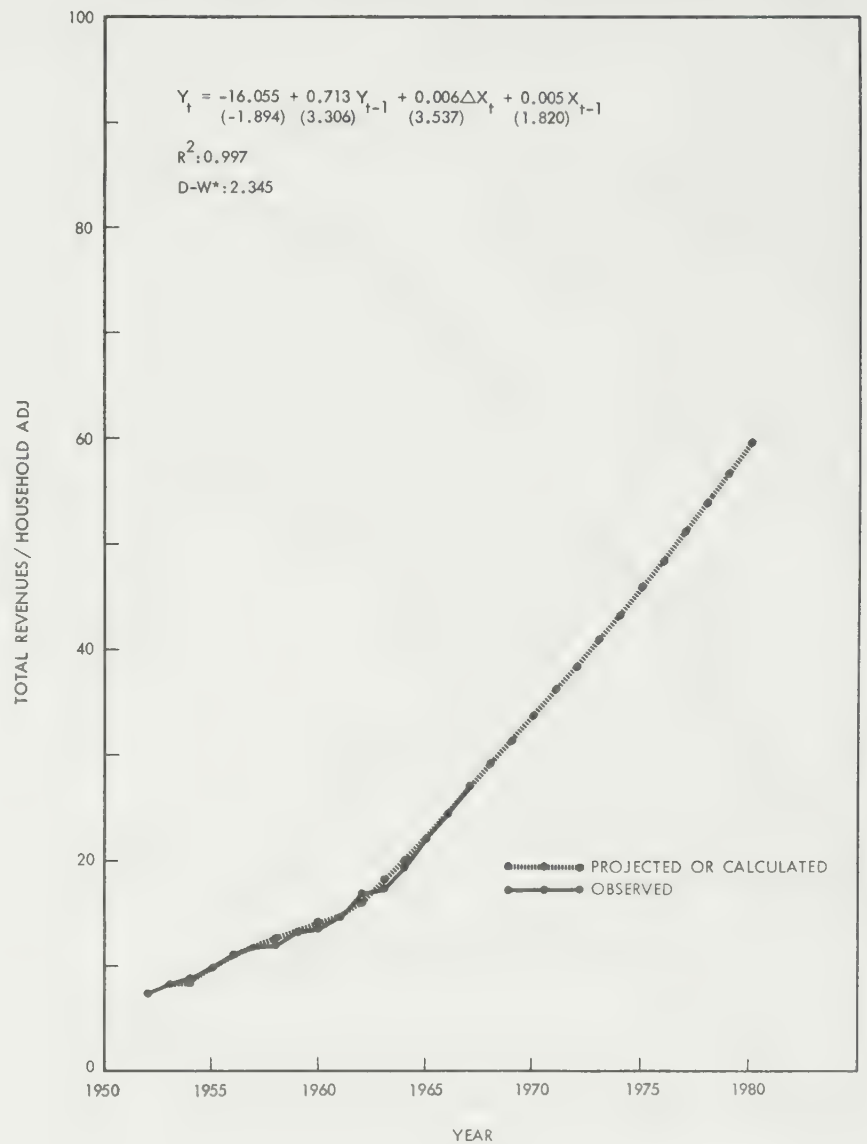


FIGURE 4.6

TOTAL REVENUES PER HOUSEHOLD

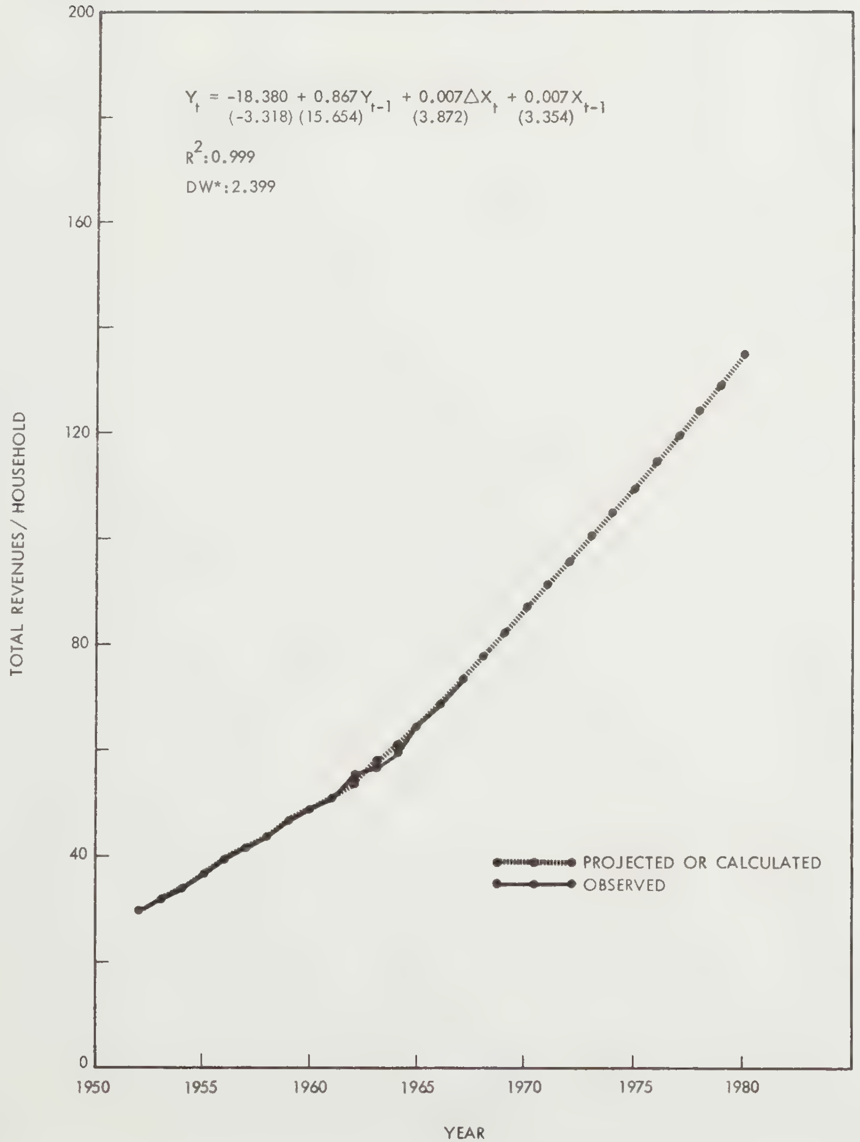


FIGURE 4.7

TOTAL REVENUES PER HOUSEHOLD ADJUSTED BY EDUCATION

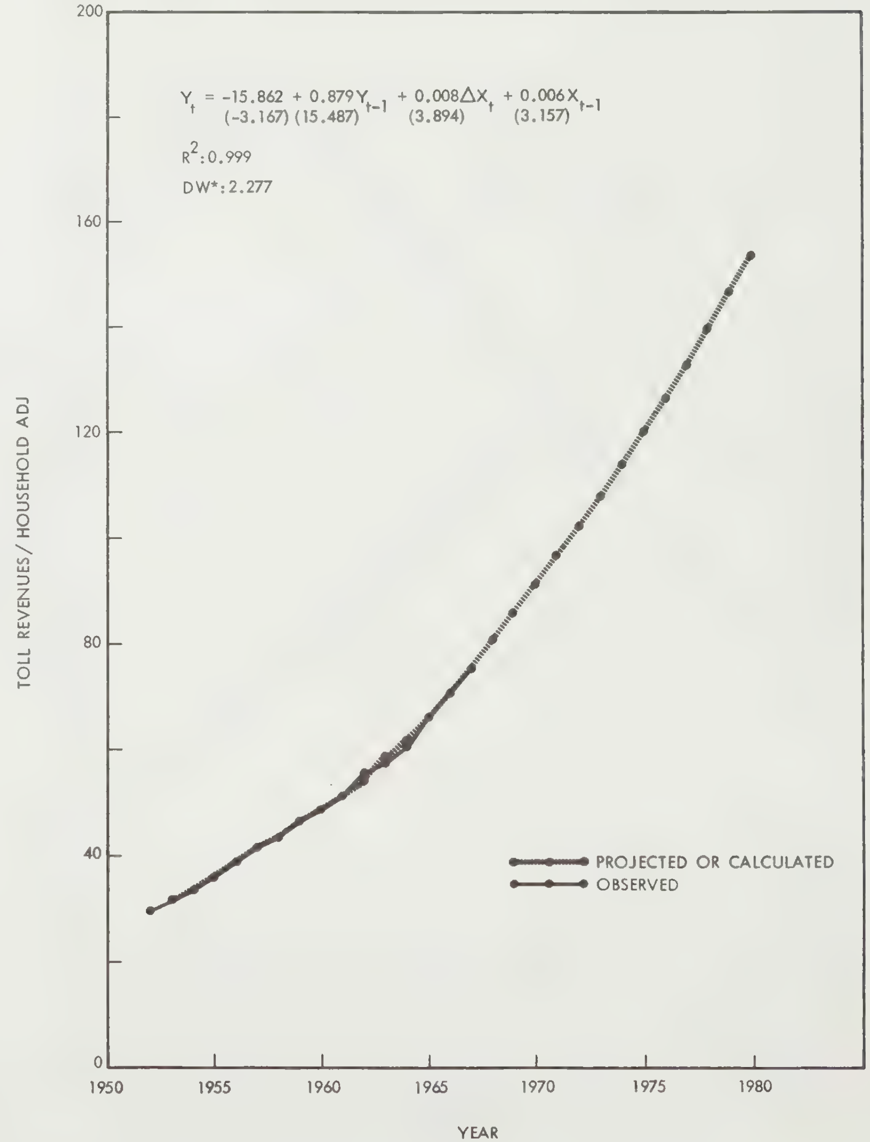


FIGURE 4.8

LOCAL REVENUES WITH PRICE VARIABLE

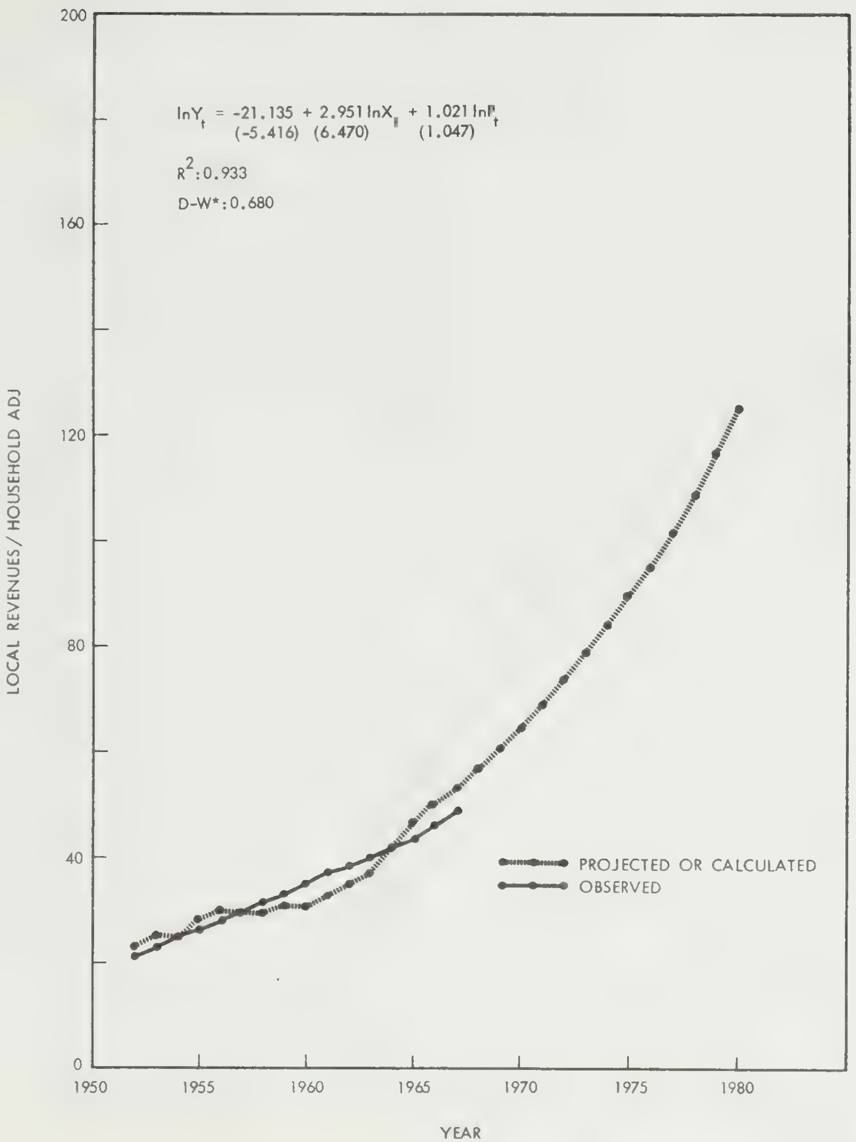


FIGURE 4.9

TOLL REVENUES WITH PRICE VARIABLE

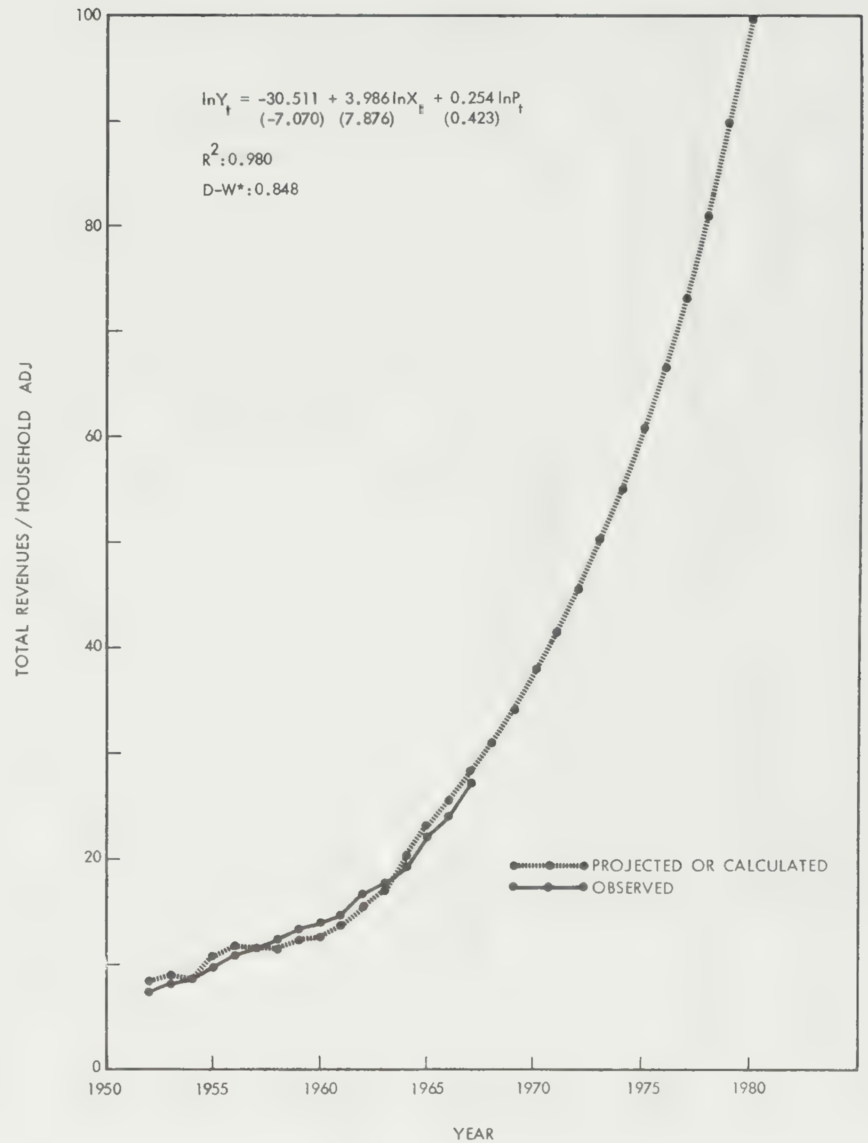
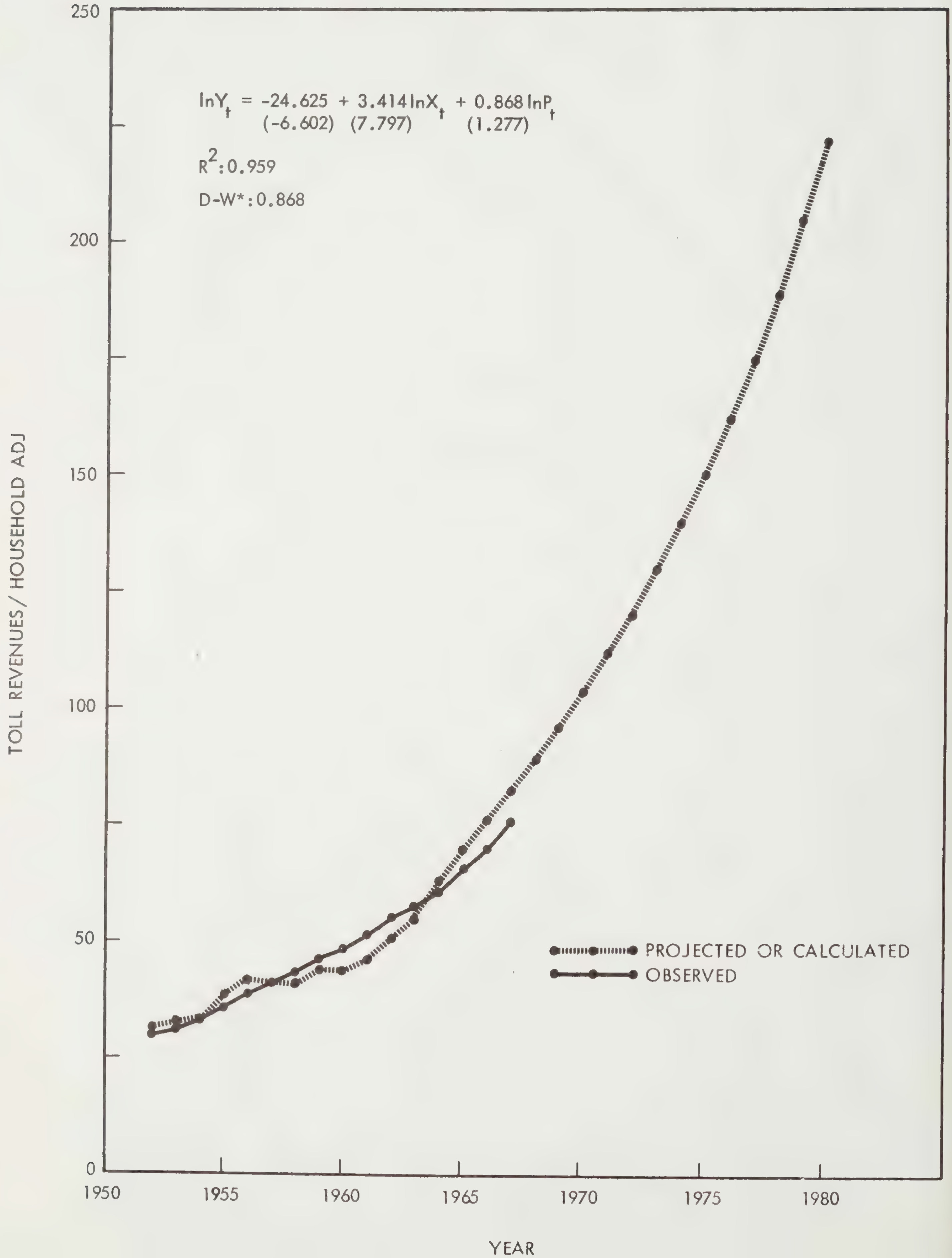


FIGURE 4.10

TOTAL REVENUES WITH PRICE VARIABLE



projections--in the case of the price variable, substantially.

A comparative view of the impact of these alternative specifications may be obtained by inspection of Figures 4.2 - 4.10. It can be seen that the effect of the education adjustment is negligible in the case of local service, but significant (at least in its cumulative effect to 1980) for the toll service projections.

The inclusion of the price variable, on the other hand, produces projections of a different order of magnitude. The average per cent rate of growth in this case being 8.9 in comparison with 6.6 for the basic specification. The underlying cause for this difference appears to be the downward drift in the relative price of telephone service over the sample period. In making projections with the price variable included, price movements were projected by extrapolation of a linear trend fitted to the relative price data. The relative price variable was calculated as the ratio of the implicit deflater for the relevant class of telephone service to the Consumer Price Index. The interpretation of these projections should therefore incorporate the assumption that technological change, the evolution of scale economies and other factors bearing on productivity will continue at the same pace as in the decade of the 1960's and that these developments will result in price reductions to the household consumer. In short, the projections including price may be viewed as establishing the upper bound to a region which includes the "true" projection. The "standard" projections, on the other hand, may be considered the lower bound to this region.

A more precise picture of these results is provided by Table 4.2. This table shows projections (forward and backward from 1967) of local and toll revenues in constant (1967) dollars. These figures are again developed for the three alternatives; standard, education adjustment included, and education adjustment with price variable added. Also shown are the annual per cent changes for the three alternatives.

As one would almost certainly expect, the telephone industry (household component) shows a positive rate of growth for the entire projection period. Furthermore this growth rate is greater by at least one percentage point (about twenty per cent) than the real growth rate projected for the economy as a whole.

Perhaps the most unexpected and interesting feature of the table, however, is the decline in the growth rates after 1967. This decline is present both for local service and for toll service and occurs for all three variants of the demand model. It is worth noting that 1967 is the final year of the sample period. The implication is clearly that the seven or so years prior to 1968 were extraordinary with respect to the growth of household demand for telephone service. There is a distinct turning point in the rate of growth in 1968. Furthermore the growth rate is predicted to decline at least until 1972. For two of the variants it continues to decline until 1980. Only in the third, where we postulate a

Table 4.2

TELEPHONE INDUSTRY REVENUES UNDER ALTERNATIVE SPECIFICATIONS*

YEAR	STANDARD SPECIFICATION				WITH EDUCATION ADJUSTMENT				WITH EDUCATION ADJUSTMENT AND PRICE			
	LOCAL		TOLL		LOCAL		TOLL		LOCAL		TOLL	
	1967 Dollars	Per Cent Change	1967 Dollars	Per Cent Change	1967 Dollars	Per Cent Change	1967 Dollars	Per Cent Change	1967 Dollars	Per Cent Change	1967 Dollars	Per Cent Change
1961	172.0	7.32	74.8	9.23	172.0	7.32	74.8	9.23	172.0	7.32	74.8	9.23
1962	183.6	6.31	89.2	16.07	183.6	6.31	89.2	16.07	183.6	6.31	89.2	16.07
1963	194.6	5.63	96.3	7.39	194.6	5.63	96.3	7.39	194.6	5.63	96.3	7.39
1964	208.1	6.49	109.7	12.25	208.1	6.49	109.7	12.25	208.1	6.49	109.7	12.25
1965	224.2	7.21	130.5	15.91	224.2	7.21	130.5	15.91	224.2	7.21	130.5	15.91
1966	243.2	7.85	148.0	11.87	243.3	7.85	148.0	11.87	243.3	7.85	148.0	11.87
1967	262.6	7.35	172.4	14.14	262.6	7.35	172.4	14.14	262.6	7.35	172.4	14.14
1968	281.6	7.21	190.1	10.27	281.4	7.14	190.1	10.23	289.0	10.03	196.8	14.12
1969	301.7	7.14	208.8	9.81	301.3	7.09	208.8	9.86	315.2	9.09	221.6	12.60
1970	322.9	7.04	228.3	9.32	322.4	6.99	228.4	9.40	343.3	8.91	248.9	12.36
1971	345.3	6.95	248.5	8.87	344.6	6.88	248.9	8.98	373.3	8.73	279.1	12.11
1972	369.0	6.85	269.6	8.48	368.0	6.80	270.4	8.63	405.6	8.64	312.6	12.00
1973	393.9	6.74	291.5	8.15	392.6	6.68	292.9	8.33	440.8	8.68	350.3	12.06
1974	420.0	6.64	314.5	7.88	418.5	6.59	316.7	8.09	479.1	8.70	392.7	12.10
1975	446.5	6.53	338.6	7.67	445.6	6.48	341.6	7.88	521.3	8.82	440.9	12.28
1976	476.6	6.51	364.1	7.52	474.8	6.56	368.2	7.77	565.7	8.50	492.8	11.77
1977	506.7	6.32	390.8	7.32	505.2	6.40	395.9	7.54	615.3	8.77	552.9	12.19
1978	537.9	6.15	418.9	7.20	536.5	6.20	425.1	7.38	670.8	9.02	622.5	12.59
1979	570.6	6.08	448.9	7.16	569.8	6.20	456.1	7.29	731.8	9.10	701.6	12.71
1980	604.9	6.01	480.8	7.10	604.5	6.10	488.9	7.20	798.9	9.18	791.6	12.83

* Dollar figures in millions.

continuously falling relative price does the falling growth rate reverse.

A puzzling feature of the results is the wide divergence between the projections where the price variable is included and those where it is omitted. As noted above, the t-statistic for the coefficient of price in the regression equation rejects the hypothesis that this coefficient differs from zero. On the other hand, the divergence between the two sets of projections suggests that household demand for telephone service is elastic with respect to price. This anomalous behaviour parallels the findings of Houthakker and Taylor for the United States.[1] Further study of price effects and a careful examination of the price data are needed.

Meanwhile the "preferred" projections would appear to be those generated by the variant which includes the education adjustment.

---

[1] Loc. cit. p.93

2. The Projection Method for Telegraph Service.

Household use of telecommunication facilities other than the telephone is of relatively small importance and is limited to the class of trade known as "public message" service. This service is provided in Canada by two firms; C.N. Telecommunications and C.P. Telecommunications.

A breakdown between household and other use of these facilities does not emerge from records kept by the companies. This fact eliminates the possibility of estimating a demand function of the type applied to the telephone industry. It was, however, felt that some assessment of the present and future role of this industry in household communications is necessary in order to give a complete picture and to place the telephone and telegraph industries in perspective.

The procedure followed is to fit a simple trend to deflated industry revenues and to extrapolate this trend to 1980. The items of revenue to which the trend is fitted are those relevant to the household sector: public message tolls and express money orders. In order to make the results comparable to those for the telephone industry the revenues were deflated using the D.B.S. telecommunication deflater.

The results are shown in Figures 4.11 - 4.13. The trend lines for both companies, and of course for the total as well, have marked downward slopes reflecting the well known secular decline in use of public message services. The vertical scales represent total use -- household and commercial -- and it is necessary for the purposes of this study to attempt a separation of the two. The only information available is that about 15 per cent of the total revenues in this category has historically been derived from the household sector.[1]

---

[1] Private correspondence with industry official.

FIGURE 4.11

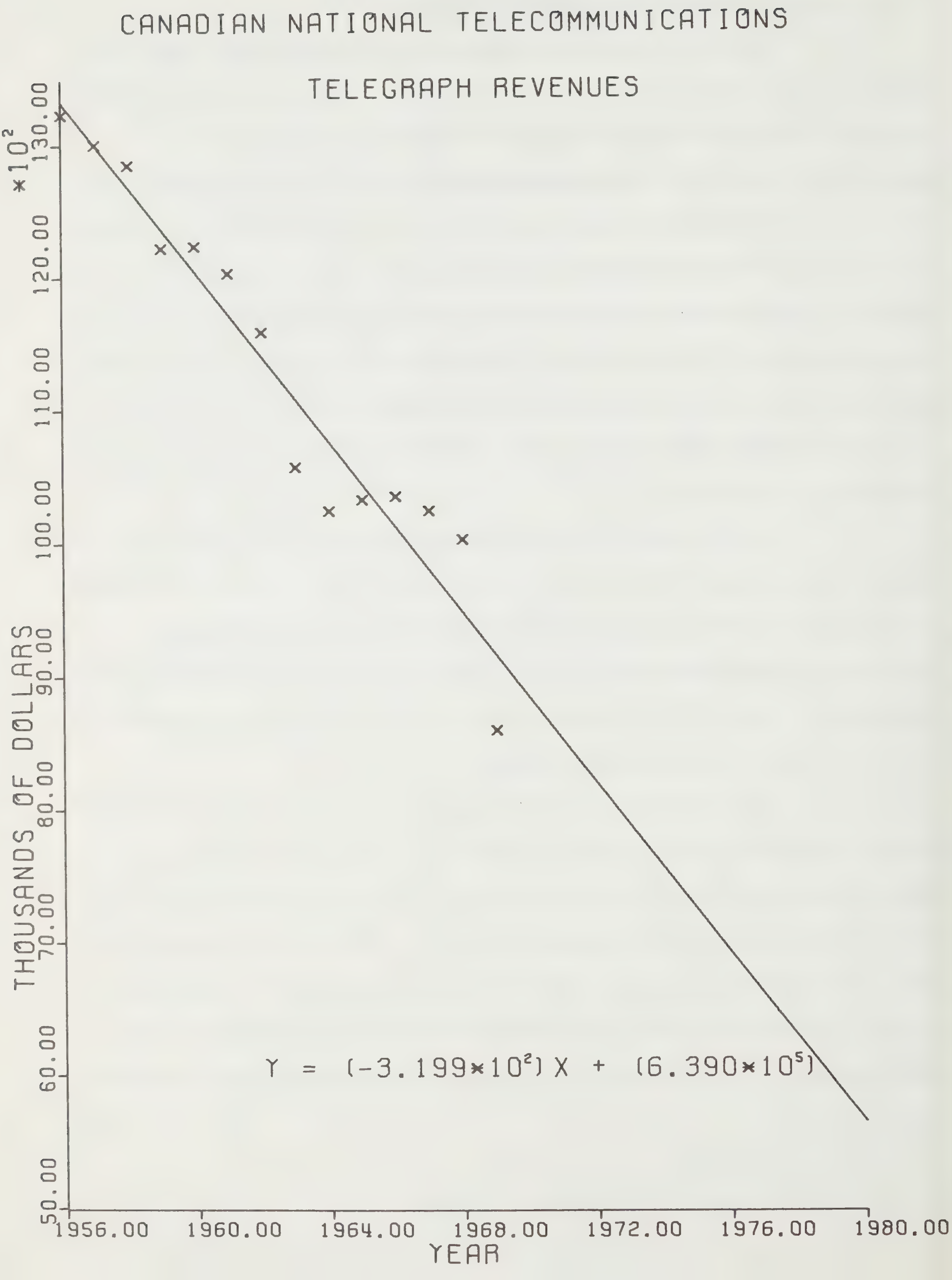

CANADIAN NATIONAL TELECOMMUNICATIONS
TELEGRAPH REVENUES
THOUSANDS OF DOLLARS
*10²
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
130.00
Y = (-3.199*10²) X + (6.390*10⁵)
1956.00
1960.00
1964.00
1968.00
1972.00
1976.00
1980.00
YEAR

FIGURE 4.12

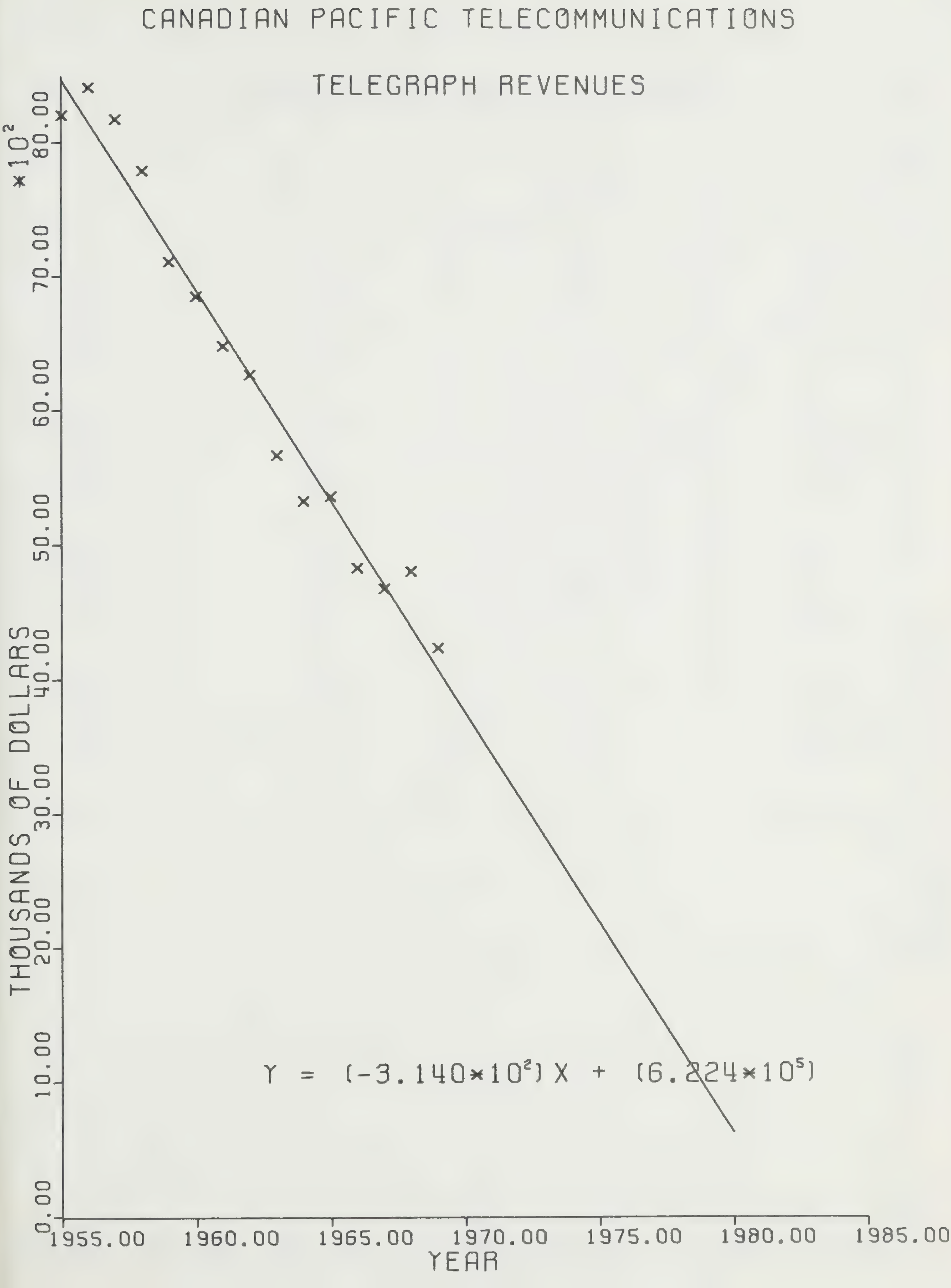

CANADIAN PACIFIC TELECOMMUNICATIONS
TELEGRAPH REVENUES
THOUSANDS OF DOLLARS
*10²
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
Y = (-3.140*10²) X + (6.224*10⁵)
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
1985.00
YEAR

FIGURE 4.13

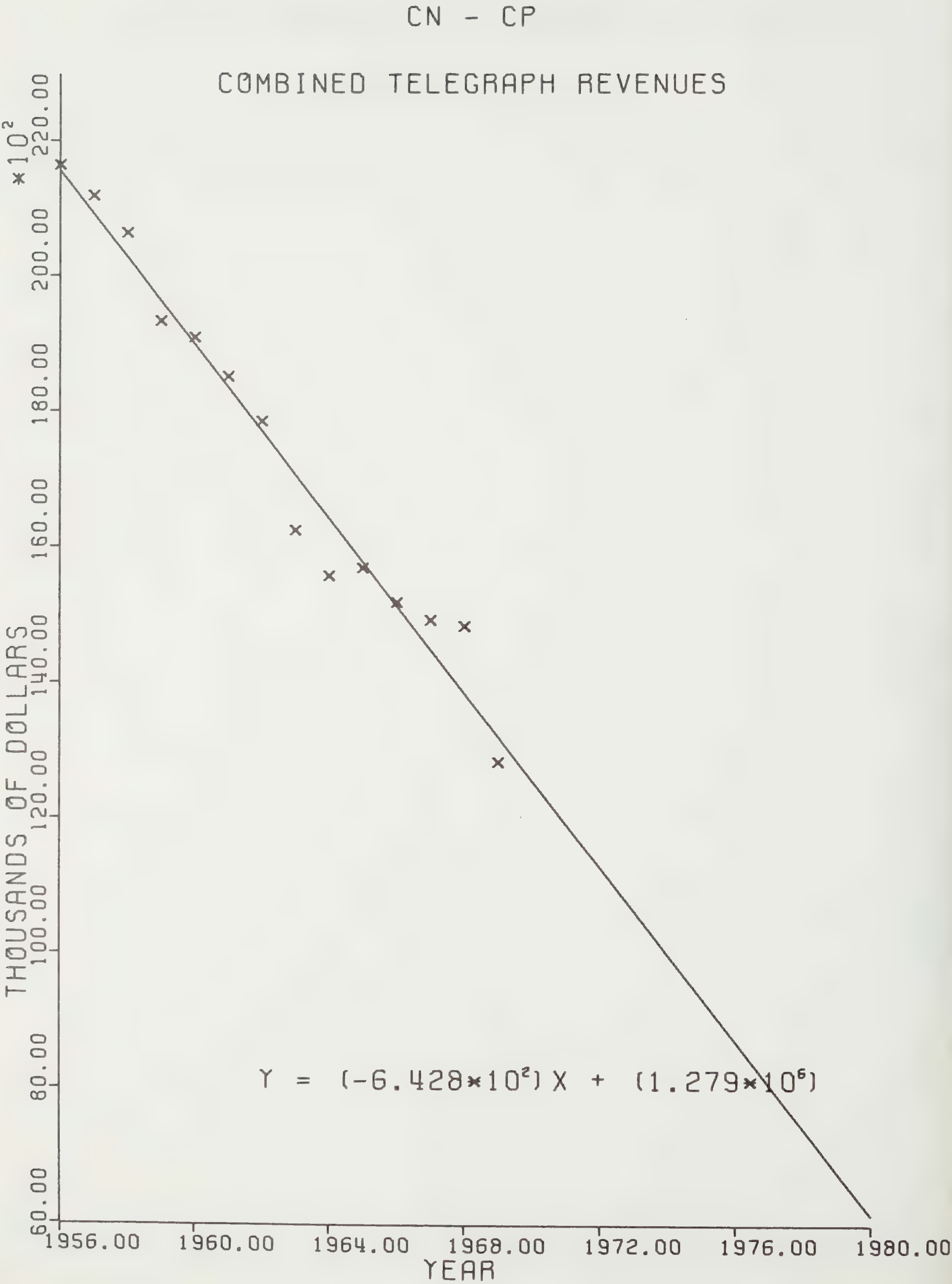

CN - CP
COMBINED TELEGRAPH REVENUES
THOUSANDS OF DOLLARS
*10²
220.00
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
Y = (-6.428*10²) X + (1.279*10⁶)
1956.00
1960.00
1964.00
1968.00
1972.00
1976.00
1980.00
YEAR

Table 4.3

DEFLATED REVENUES ORIGINATING IN HOUSEHOLDS
(Millions of 1967 dollars)

Year	Telephone*	Telegraph	Total
1961	246.8	2.8	249.6
1962	272.8	2.7	275.5
1963	290.9	2.4	293.3
1964	317.8	2.3	320.1
1965	354.7	2.4	357.1
1966	391.3	2.3	393.6
1967	435.0	2.2	437.2
1968	461.5	2.2	463.7
1969	510.1	1.9	512.0
1970	550.8	1.9	552.7
1971	593.5	1.8	595.3
1972	638.4	1.7	640.1
1973	685.5	1.6	687.1
1974	735.2	1.5	736.7
1975	787.2	1.4	788.6
1976	843.0	1.3	844.3
1977	901.1	1.2	902.3
1978	961.6	1.1	962.7
1979	1025.9	1.0	1026.9
1980	1093.4	0.9	1094.3

*Sum of local and toll derived from "Education Adjustment" variant in Table 4.2.

The figures derived using this rough approximation are shown in Table 4.3. Also shown in this table are the "preferred" projections for the telephone industry and the totals for the two branches of the telecommunications industry. The conclusion to be drawn from this table is that household use of the telegraph medium is small relative to household use of the telephone and will become smaller. In 1961 the size of the telegraph sector was one per cent of the telephone sector. This ratio is projected to decline to one tenth of one per cent by 1980. The method of analysis of the telegraph industry is admittedly somewhat crude, but it seems unlikely that refinement of the analysis or of the data will substantially alter this result.

APPENDIX A.

Data and Sources

APPENDIX TABLE A.1

Families and Households (Thousands)

Year	Family* (1)	Non Family* (2)	Total Households* (3)	Education Index (4)	Total House-Holds Adjusted**
1950	2951	457	3407	0.9910	3438
1951	3029	469	3497	0.9944	3517
1952	3127	474	3601	0.9958	3616
1953	3224	482	3705	0.9974	3715
1954	3320	495	3815	0.9985	3821
1955	3403	512	3915	1.000	3915
1956	3496	532	4028	1.0019	4020
1957	3623	555	4178	1.0022	4169
1958	3710	581	4291	1.0034	4267
1959	3796	609	4405	1.0061	4378
1960	3886	640	4526	1.0090	4486
1961	3962	672	4634	1.0120	4579
1962	4023	707	4731	1.0160	4657
1963	4092	743	4835	1.0198	4741
1964	4170	779	4948	1.0239	4833
1965	4259	814	5074	1.0284	4934
1966	4364	850	5214	1.0333	5046
1967	4462	882	5344	1.0383	5147
1968	4565	914	5480	1.0438	5250
1969	4676	946	5622	1.0495	5357
1970	4793	976	5769	1.0557	5465
1971	4915	1007	5922	1.0624	5574
1972	5044	1037	6081	1.0694	5686
1973	5178	1067	6245	1.0769	5799
1974	5316	1097	6414	1.0847	5913
1975	5459	1128	6587	1.0929	6027
1976	5612	1158	6770	1.1002	6153
1977	5763	1188	6951	1.1076	6276
1978	5911	1218	7129	1.1150	6394
1979	6062	1248	7310	1.1225	6512
1980	6215	1278	7493	1.1300	6631

*Source: Illing, Wolfgang M. et al, Population, Family, Household and Labour Force Growth, Staff Study #19, pages , Economic Council of Canada, Ottawa.

**The Adjustment consists of dividing the figures in Column (3) by Column (4).

APPENDIX TABLE A.2

Gross Domestic Product and Personal Consumption Expenditures
(Millions of 1949 Dollars)

Year	Gross Domestic Product Actual*	Annual Rate of Growth of Potential Output	Personal Consumption Exp Actual*
1950	16458		
1951	19126		11817
1952	21344		12633
1953	22206		13338
1954	23213		13650
1955	24169		14738
1956	26936		15516
1957	28455		16058
1958	29318		16568
1959	31293		17281
1960	32146		17774
1961	33351		18508
1962	36137		19364
1963	38697		20235
1964	41675		21506
1965	45793		22798
1966	50741		23954
1967	54166		25094
	Potential Projected**		Potential Projected
1968	56885	5.02	26226
1969	59769	5.07	27461
1970	62859	5.17	28735
1971	66103	5.16	30050
1972	69553	5.22	31419
1973	73239	5.30	32850
1974	77136	5.32	34346
1975	81240	5.32	35914
1976	85537	5.29	37559
1977	90037	5.26	39286
1978	94745	5.23	41098
1979	99672	5.20	42998
1980	104825	5.17	44989

*Source: Dominion Bureau of Statistics, National Accounts, Income and Expenditure 1926-1956.

**Source: See Text.

APPENDIX TABLE A.3

Education Index

Year	Education Index	Year	Education Index
1950	0.9910	1966	1.0333
1951	0.9944	1967	1.0383
1952	0.9958	1968	1.0438
1953	0.9974	1969	1.0495
1954	0.9985	1970	1.0557
1955	1.0000	1971	1.0624
1956	1.0019	1972	1.0694
1957	1.0022	1973	1.0769
1958	1.0034	1974	1.0847
1959	1.0061	1975	1.0929
1960	1.0090	1976	1.1002
1961	1.0120	1977	1.1076
1962	1.0160	1978	1.1150
1963	1.0198	1979	1.1225
1964	1.0239	1980	1.1300
1965	1.0284		

Source: See Text

APPENDIX TABLE A.4

Implicit Deflaters (1967=100)

Year	Olley Study[1]			D.B.S.[2]
	Local Revenues	Toll Revenues	Combined Revenues	Combined Revenues
1952	.924	1.025	.955	
1953	.933	1.030	.963	
1954	.932	1.035	.964	
1955	.933	1.035	.966	.873
1956	.933	1.037	.967	.880
1957	.933	1.039	.967	.883
1958	.939	1.042	.972	.889
1959	1.000	1.085	1.027	.945
1960	1.000	1.095	1.031	.948
1961	1.000	1.084	1.027	.955
1962	1.000	1.030	1.010	.969
1963	1.000	1.026	1.009	.971
1964	1.000	1.025	1.009	.972
1965	1.000	1.022	1.008	.976
1966	1.000	1.006	1.002	.987
1967	1.000	1.000	1.000	1.000
1968				1.007

[1] R.E. Olley, Memorandum on Productivity, Mimeographed, Bell Canada, 1969.

[2] Dominion Bureau of Statistics, Prices and Price Indexes, Ottawa.

Note: In deriving constant (1967) dollar revenues it was necessary to choose between two sets of price deflaters: those calculated by Dr. R.E. Olley for the Bell Telephone Company of Canada and those published by the Dominion Bureau of Statistics. It was decided to use the Bell figures. The reasons for this choice were related to the coverage and to the length of the different series. The Bell series have the disadvantage that they apply only to revenues of the Bell Telephone Company of Canada, thus directly covering only about 67% of the total. On the other hand, they provide a breakdown between local and toll service (although not between household and business use).

The deflater published by the Dominion Bureau of Statistics is a component of the Consumer Price Index and applies to household telephone service. Separate deflaters for local and toll service are not published. In addition to these disadvantages the D.B.S. annual series is shorter; extending only from 1955 to 1967. It seemed advisable, in the face of these considerations to use the Bell deflaters.

It must be noted that the projections are not unaffected by this choice. The Bell index declines from 1960 to 1967, whereas the D.B.S. index shows a five point rise over the same period. In both instances the relative price of telephone service is declining but the difference in the rate of decline may be expected to affect the forecasts.

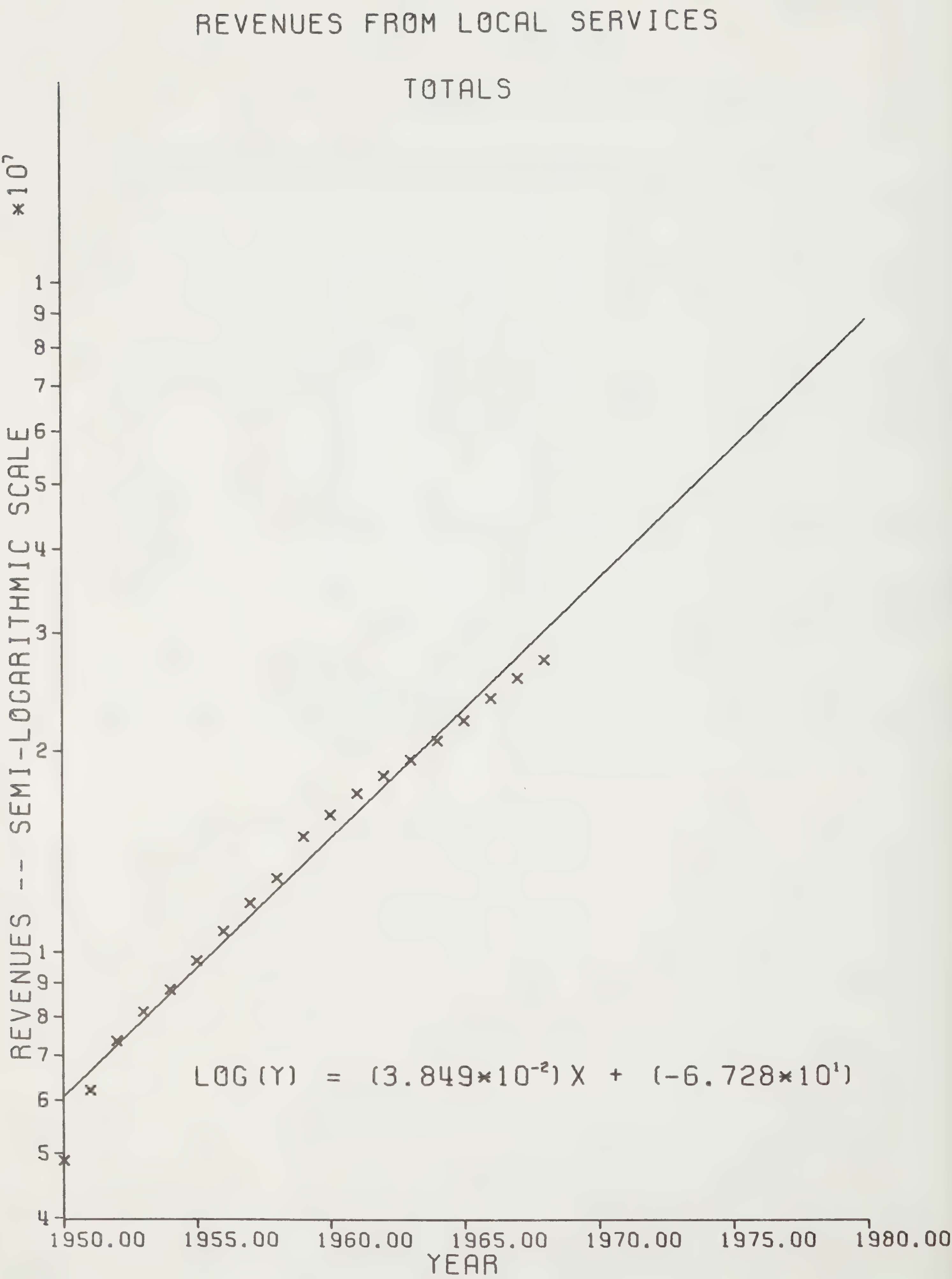
APPENDIX B.

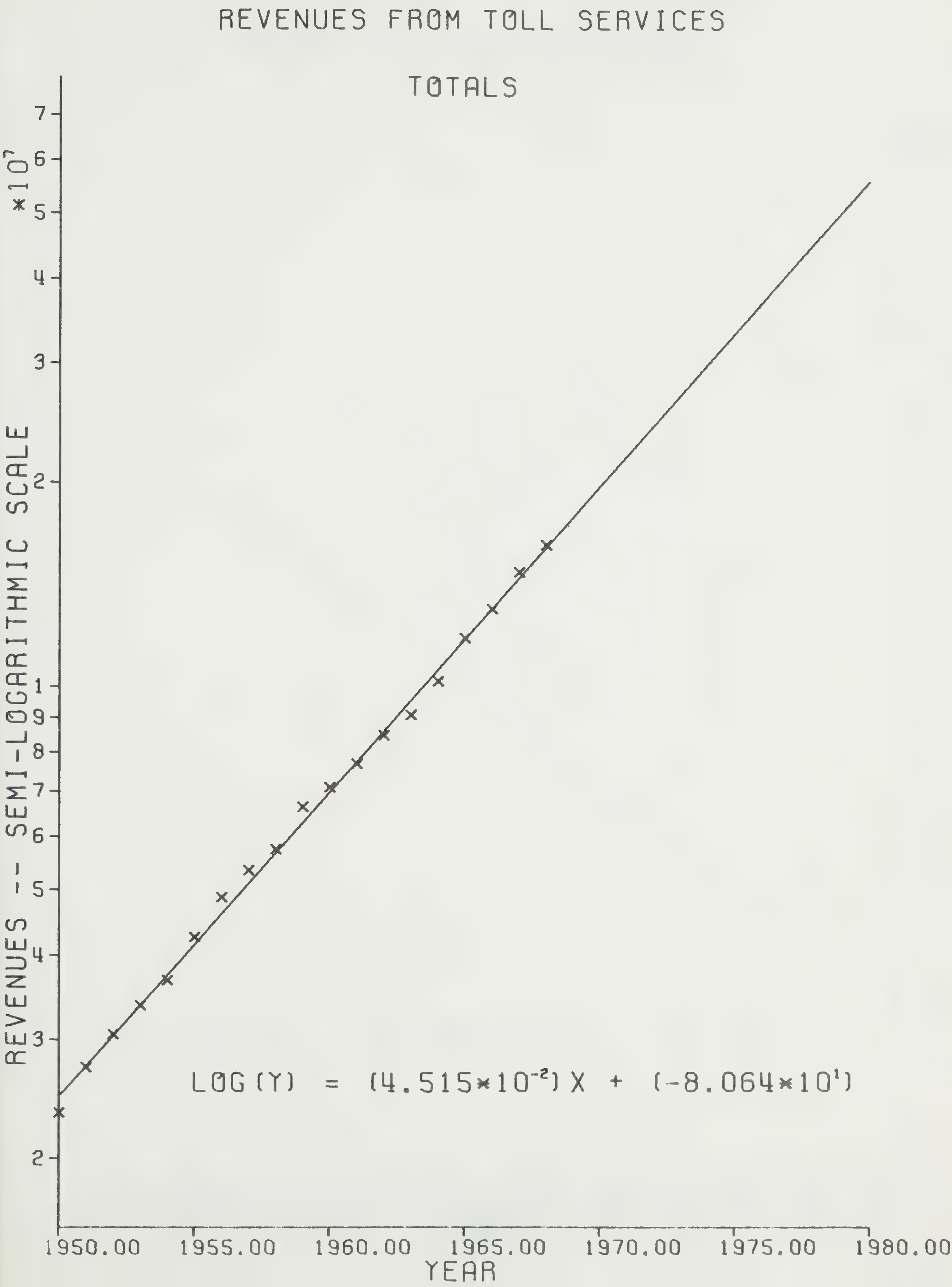
Industry Revenues by Company

One of the preliminary steps in this study was an examination of the telephone industry data in graphic form. Since growth rates were a main area of interest, the undeflated revenue data were plotted over time to a semi-logarithmic scale. Trend lines were fitted to the data in this form and the resulting equations appear on the diagrams. Since logarithms to the base 10 were used the coefficient of X cannot be interpreted as an annual rate of growth. (Division by 0.338 converts this coefficient to a growth rate.)

The patterns into which the data fall appear to be of some intrinsic interest. A clearly defined log-linear trend emerges in all cases. The points, however, seem to follow a wave configuration around the trend line. It seems likely that these waves reflect rate changes.

The trend lines themselves generate forecasts of a simple type which may be compared roughly with those generated by the more complex model.

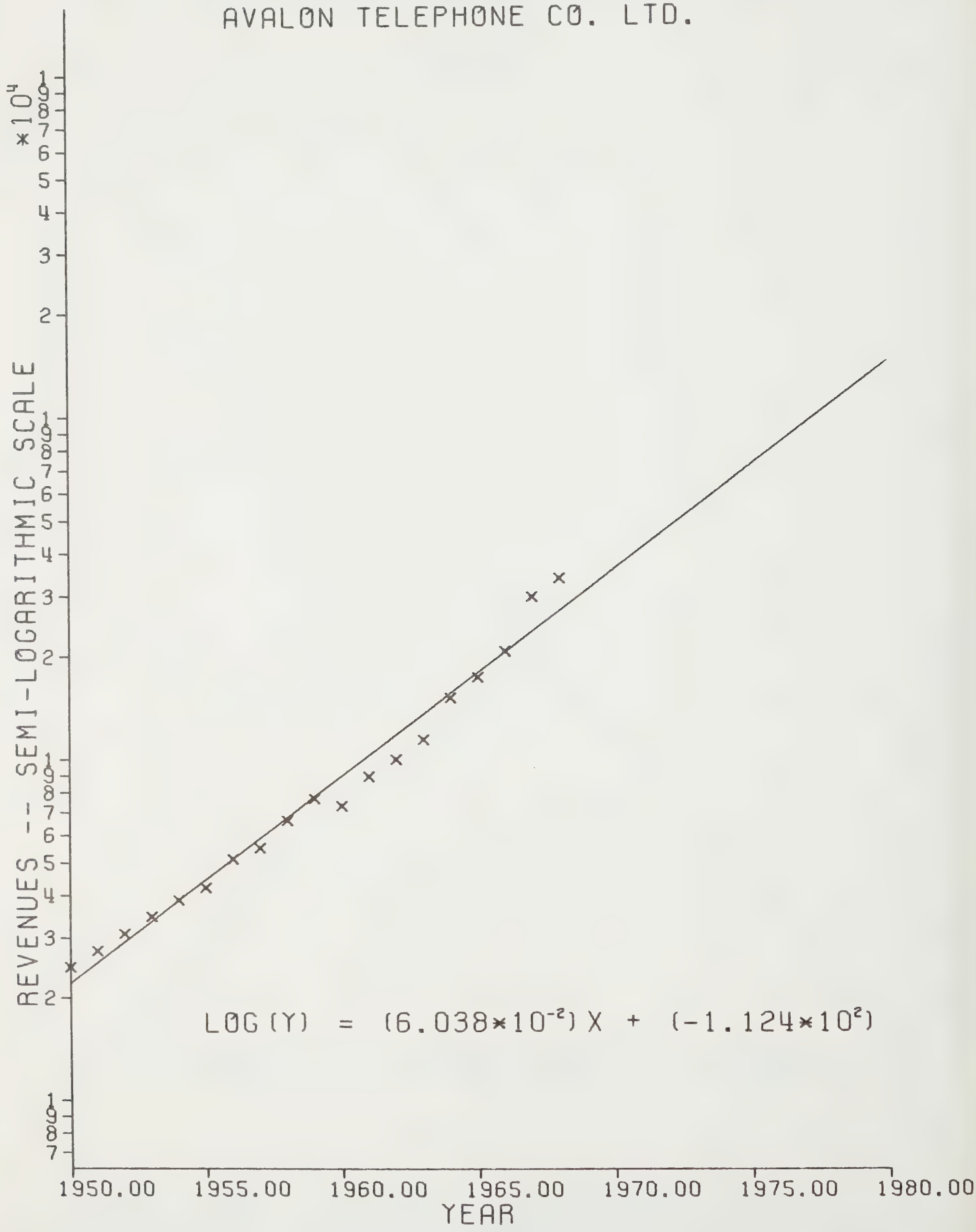

REVENUES FROM LOCAL SERVICES
TOTALS
REVENUES -- SEMI-LOGARITHMIC SCALE *10^7
LOG(Y) = (3.849*10^-2) X + (-6.728*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

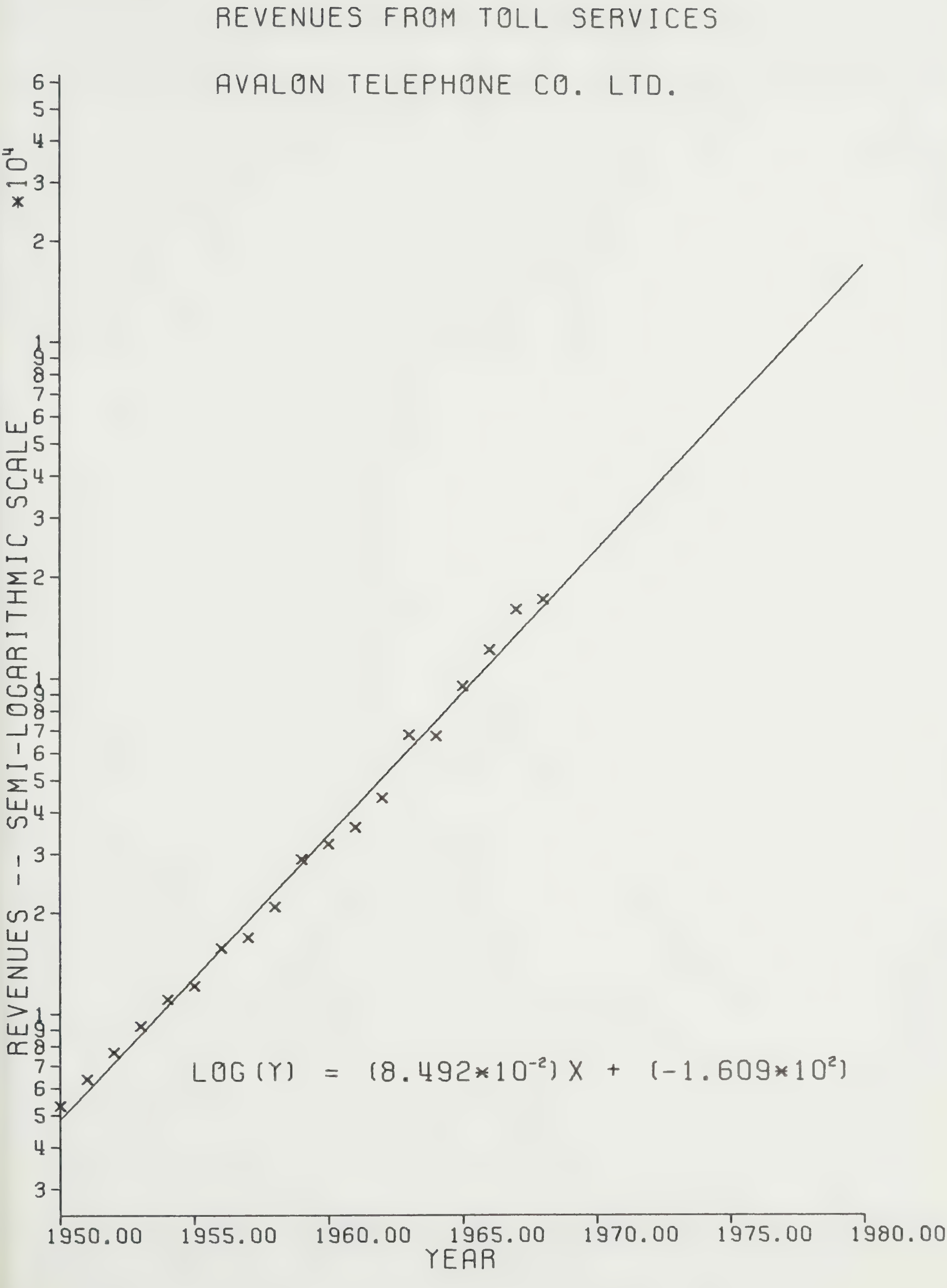


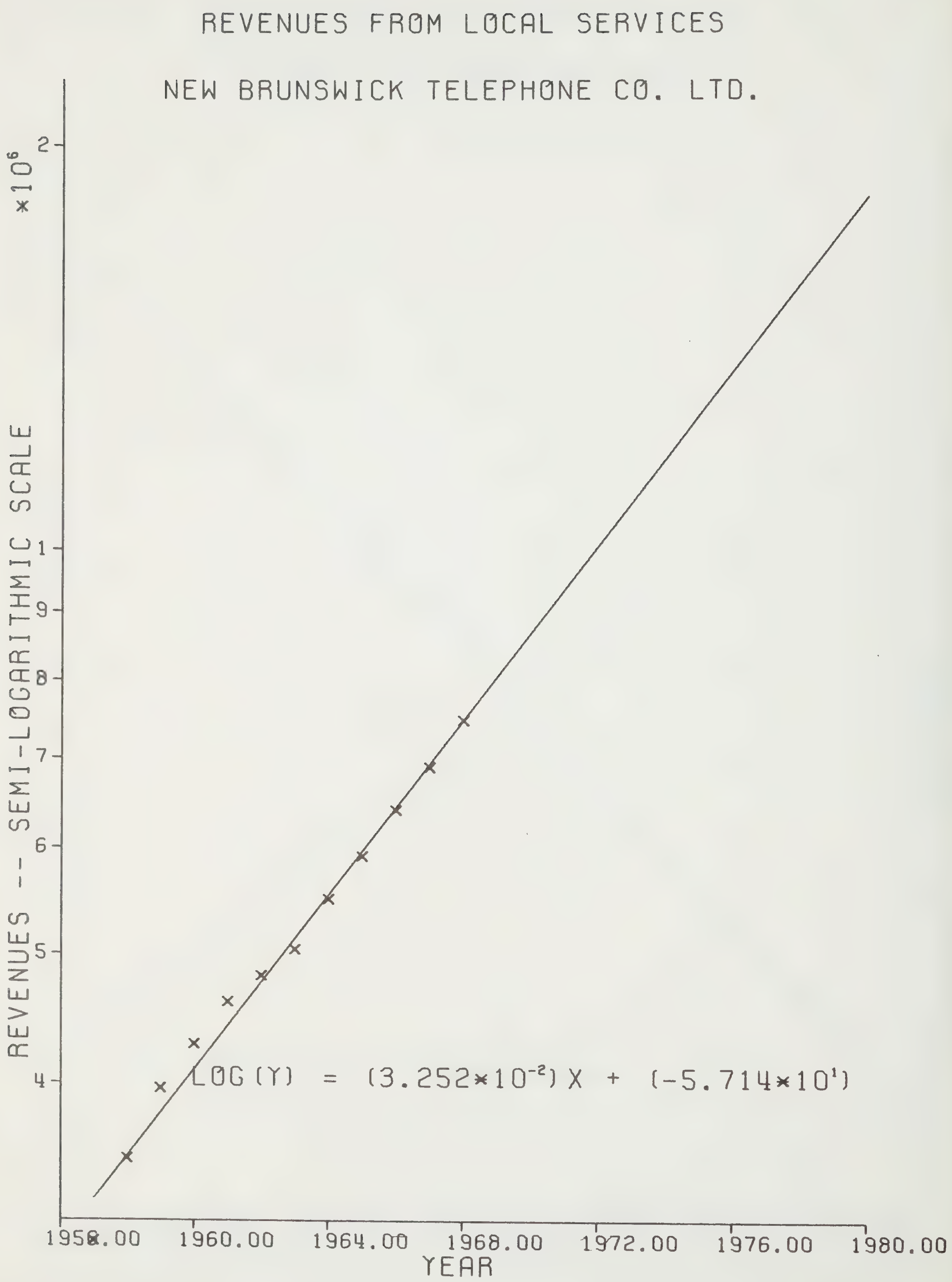
REVENUES FROM TOLL SERVICES
TOTALS
REVENUES -- SEMI-LOGARITHMIC SCALE
*10^7
7
6
5
4
3
2
1
9
8
7
6
5
4
3
2
LOG(Y) = (4.515*10^-2) X + (-8.064*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

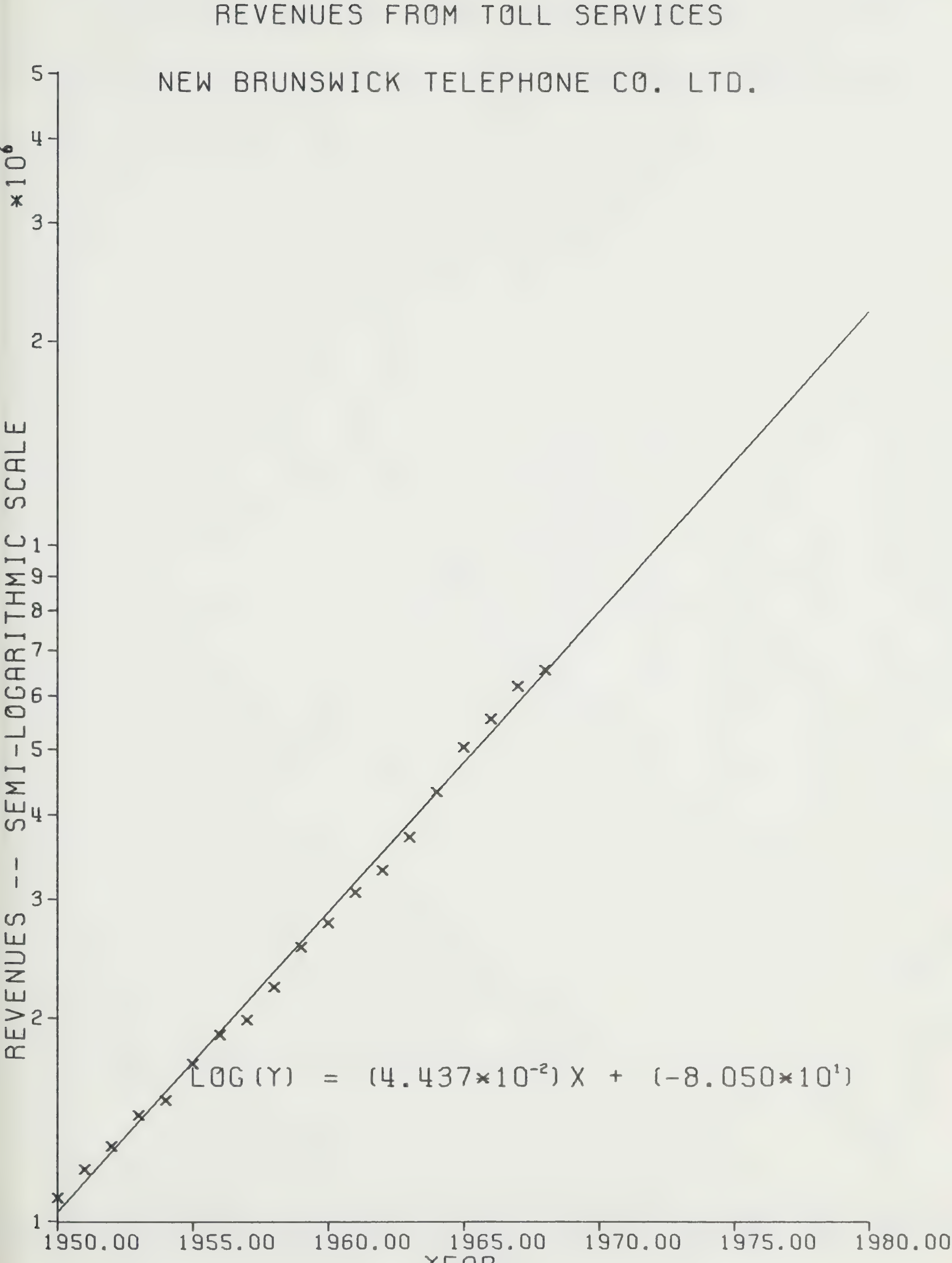
REVENUES FROM LOCAL SERVICES

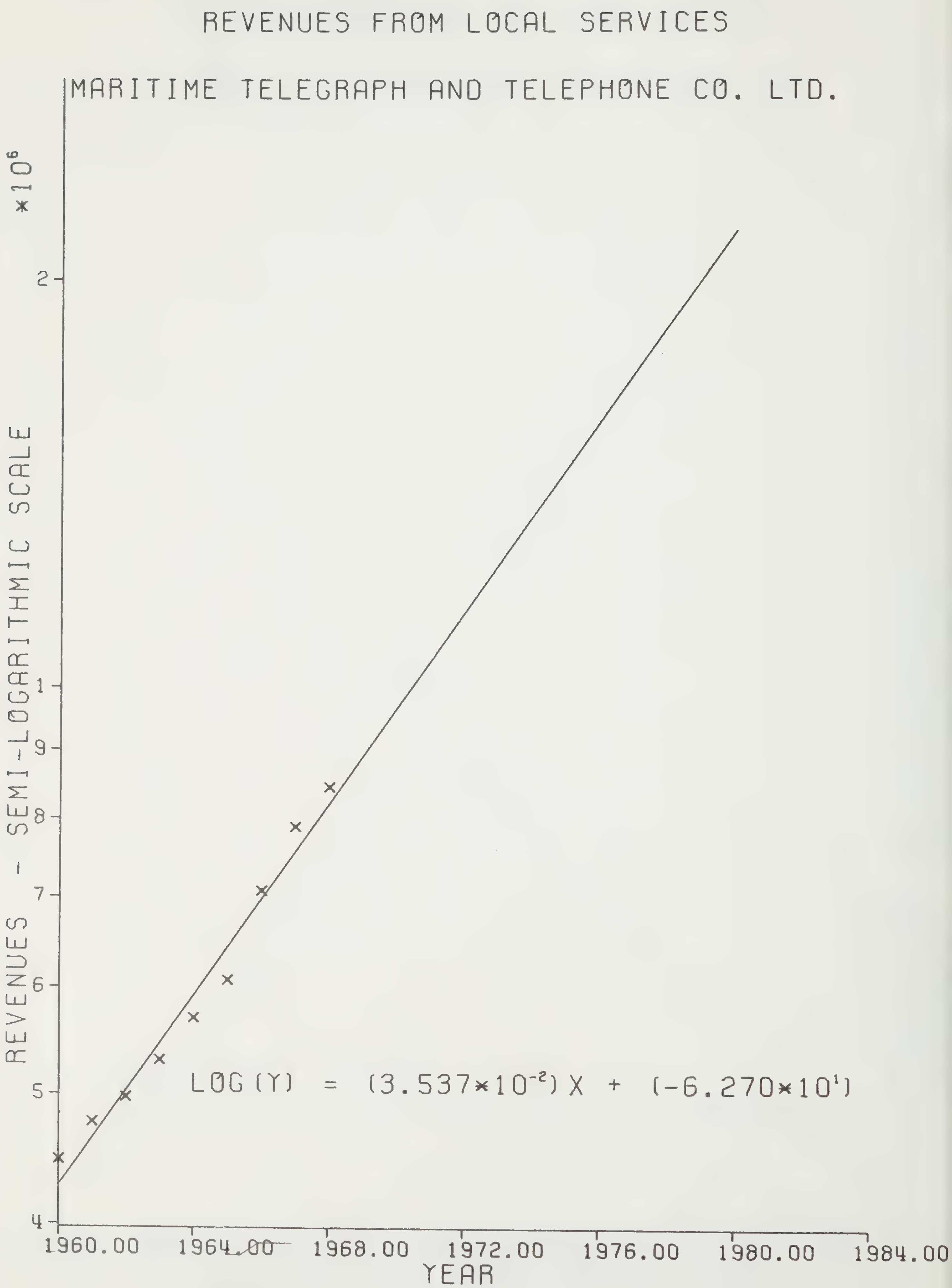
AVALON TELEPHONE CO. LTD.



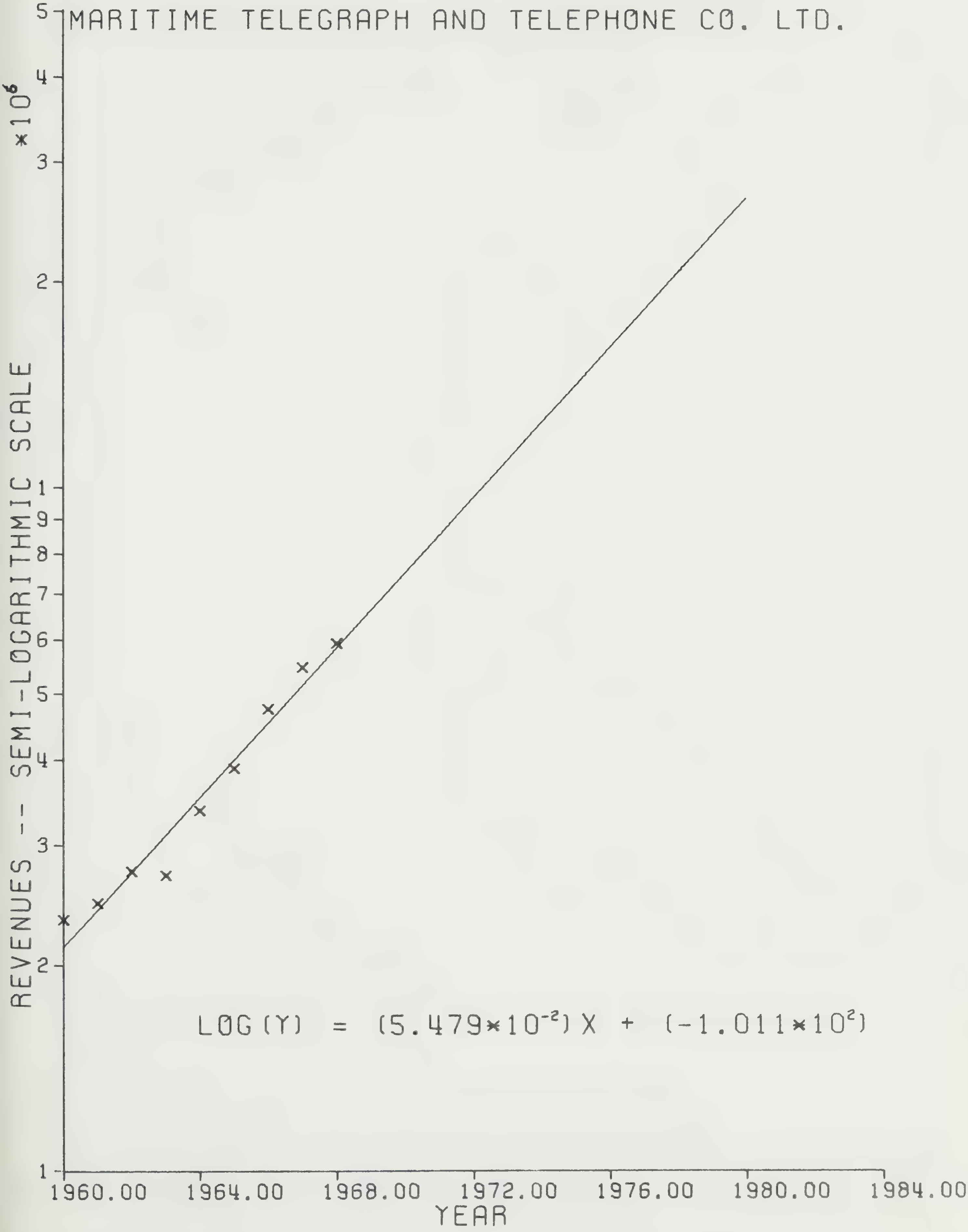

REVENUES FROM TOLL SERVICES
AVALON TELEPHONE CO. LTD.
REVENUES -- SEMI-LOGARITHMIC SCALE *10^4
LOG(Y) = (8.492*10^-2) X + (-1.609*10^2)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

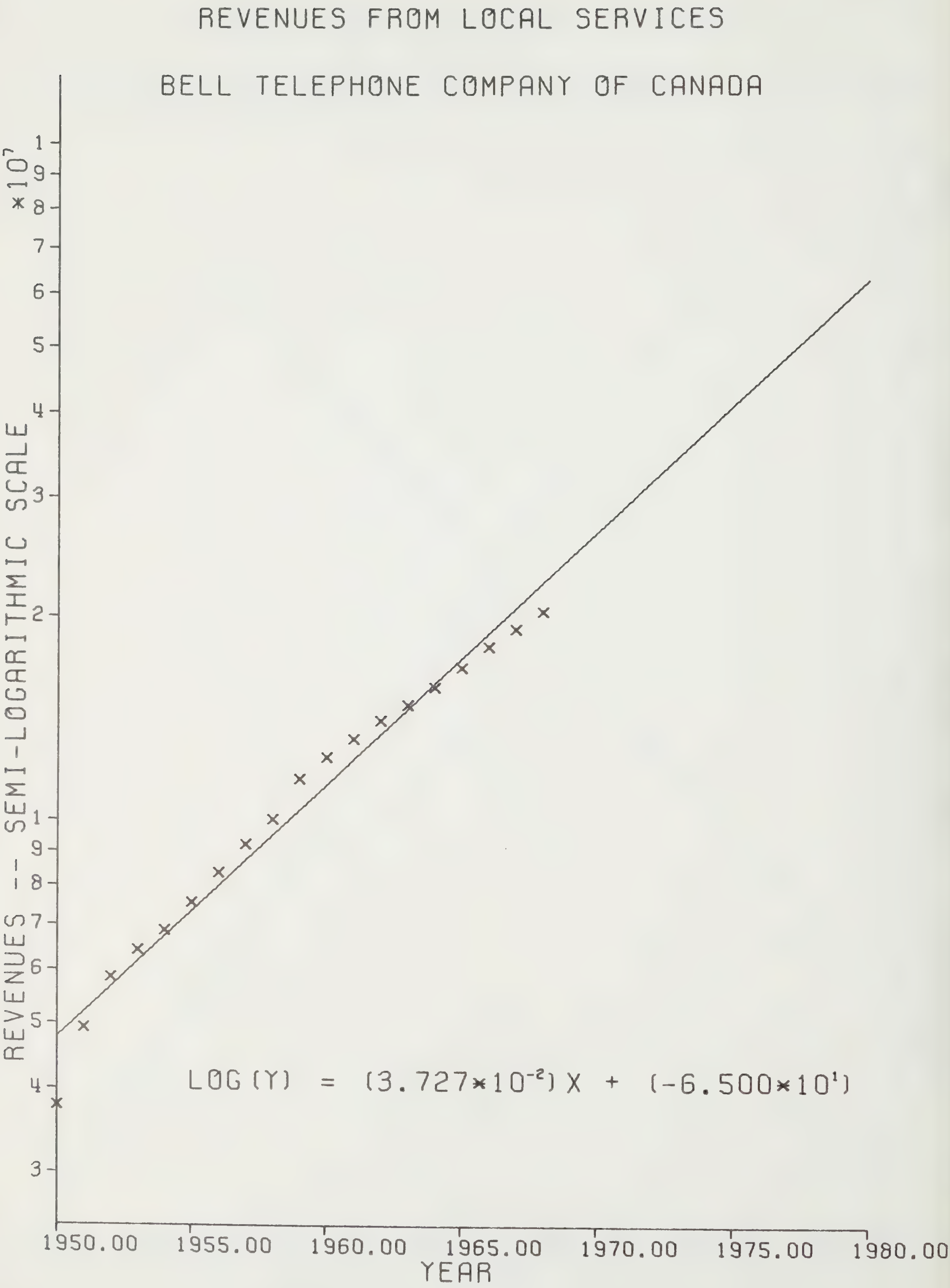

REVENUES FROM LOCAL SERVICES
NEW BRUNSWICK TELEPHONE CO. LTD.
REVENUES -- SEMI-LOGARITHMIC SCALE
$\times 10^{6}$
2
1
9
8
7
6
5
4
LOG(Y) = (3.252×10⁻²) X + (-5.714×10¹)
1958.00
1960.00
1964.00
1968.00
1972.00
1976.00
1980.00
YEAR


REVENUES FROM TOLL SERVICES
NEW BRUNSWICK TELEPHONE CO. LTD.
REVENUES -- SEMI-LOGARITHMIC SCALE
*10^6
1
2
3
4
5
6
7
8
9
1
2
3
4
5
LOG(Y) = (4.437*10^-2) X + (-8.050*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

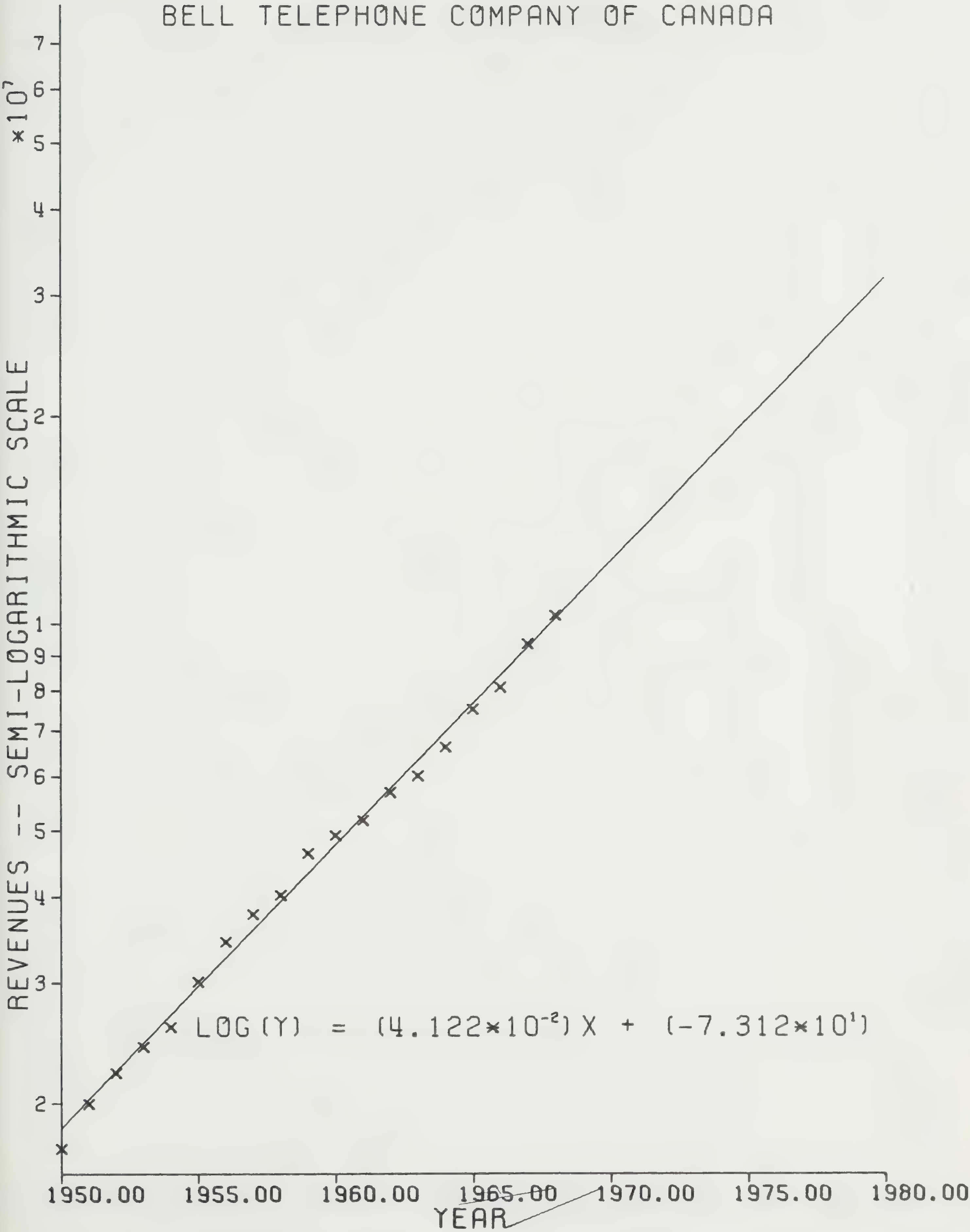

REVENUES FROM LOCAL SERVICES
MARITIME TELEGRAPH AND TELEPHONE CO. LTD.
*10^6
REVENUES - SEMI-LOGARITHMIC SCALE
2
1
9
8
7
6
5
4
LOG(Y) = (3.537*10^-2) X + (-6.270*10^1)
1960.00
1964.00
1968.00
1972.00
1976.00
1980.00
1984.00
YEAR

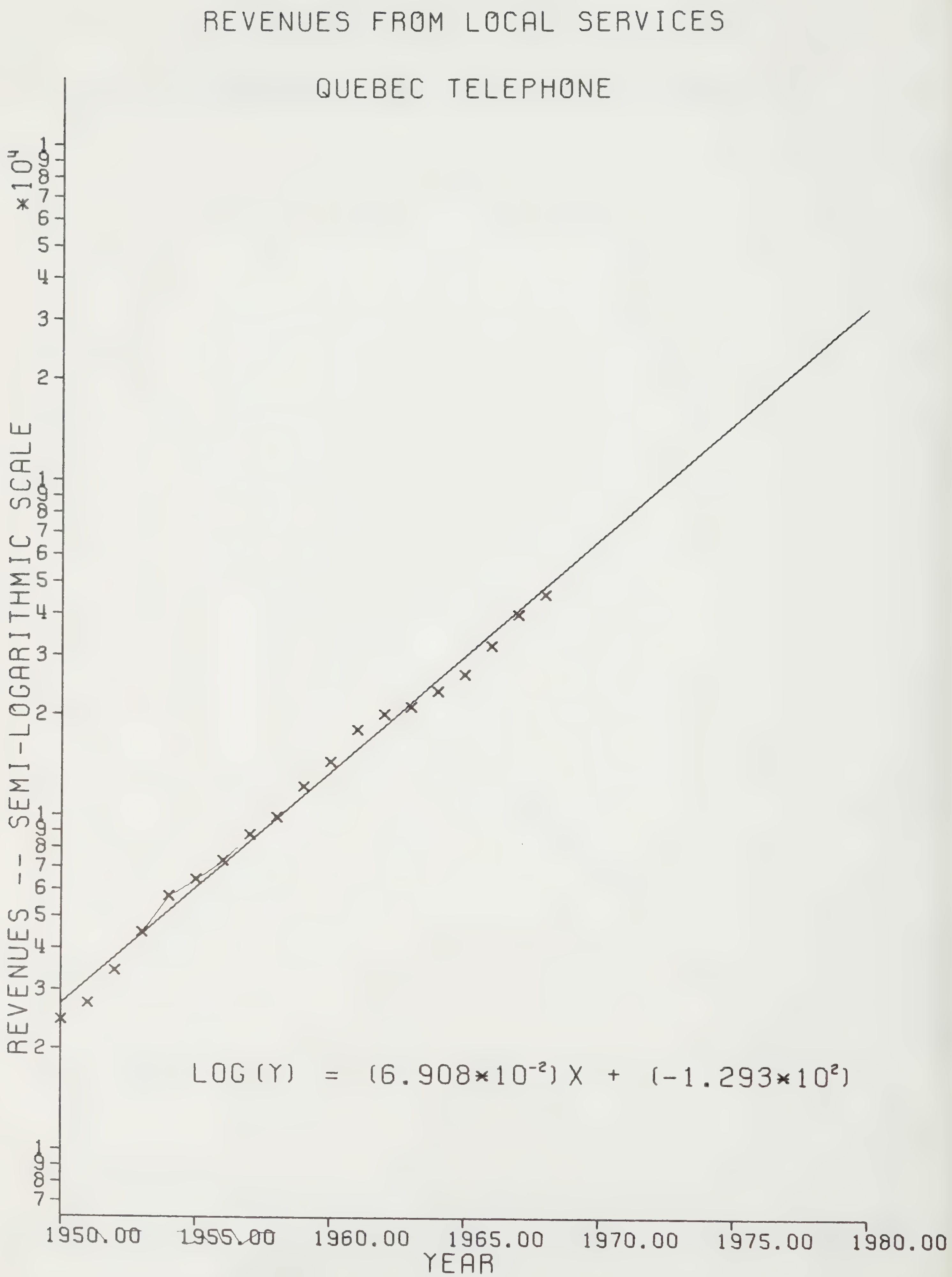
REVENUES FROM TOLL SERVICES

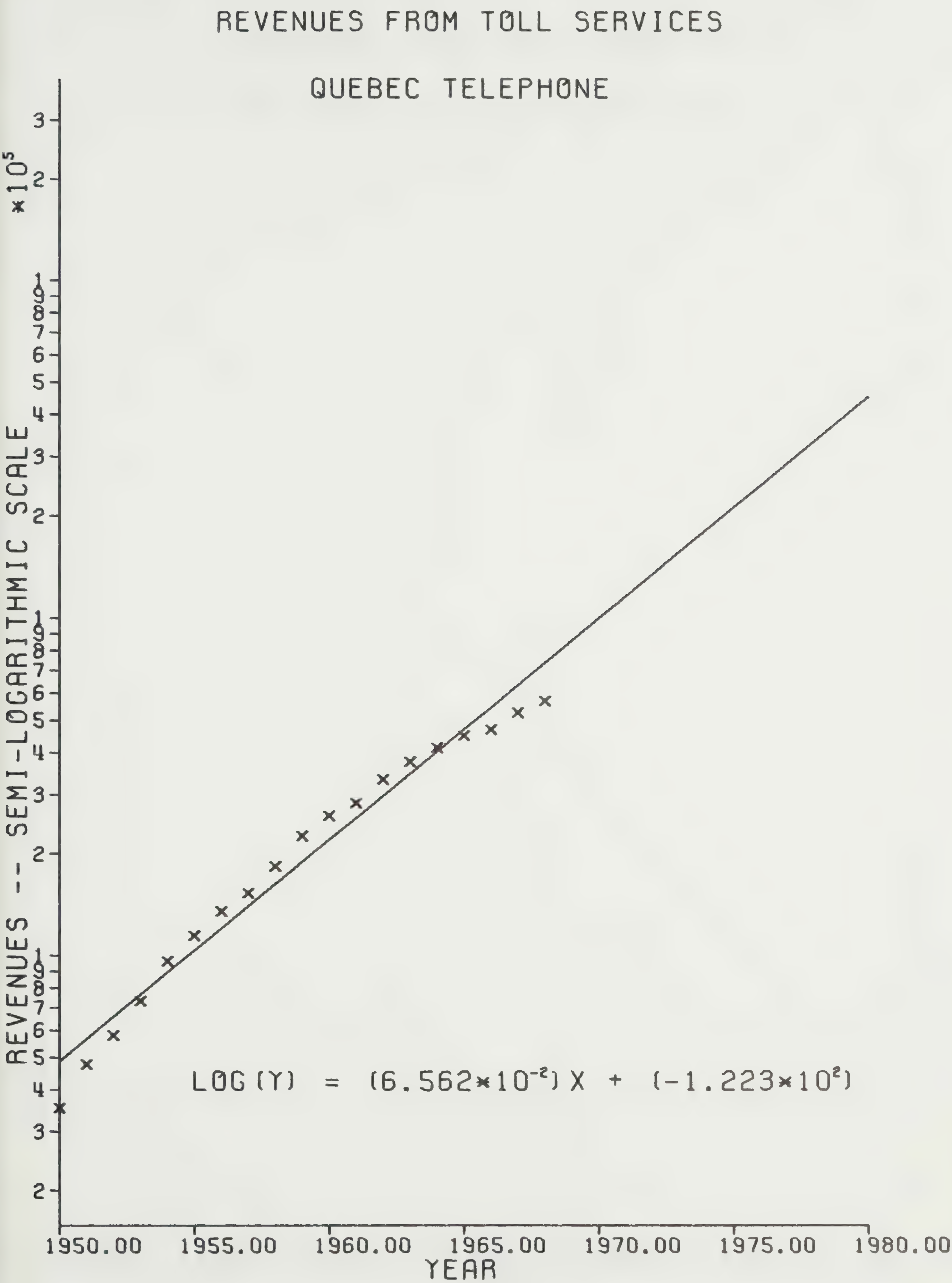


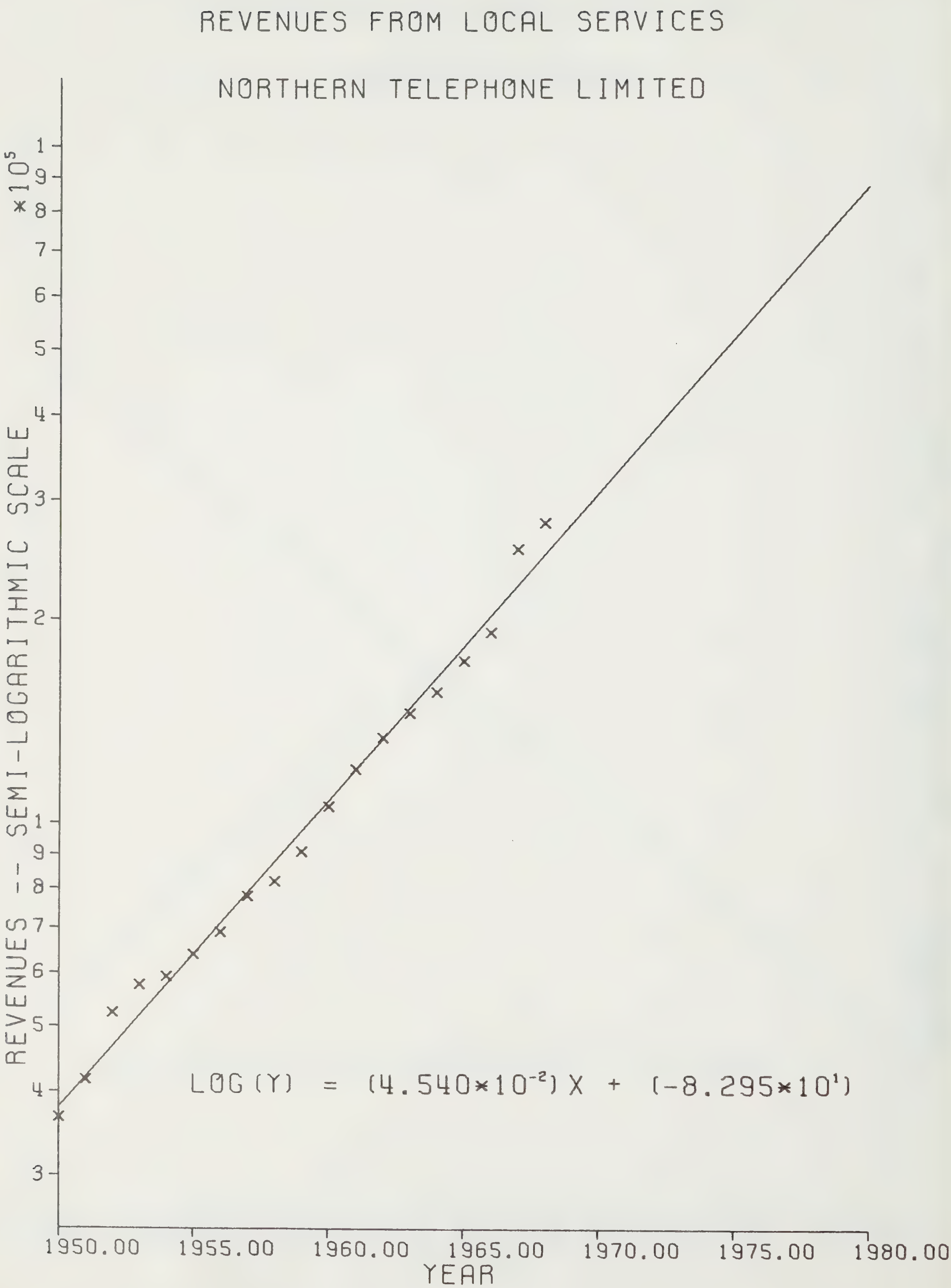

REVENUES FROM LOCAL SERVICES
BELL TELEPHONE COMPANY OF CANADA
REVENUES -- SEMI-LOGARITHMIC SCALE
*10^7
1
9
8
7
6
5
4
3
2
1
9
8
7
6
5
4
3
LOG(Y) = (3.727*10^-2) X + (-6.500*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

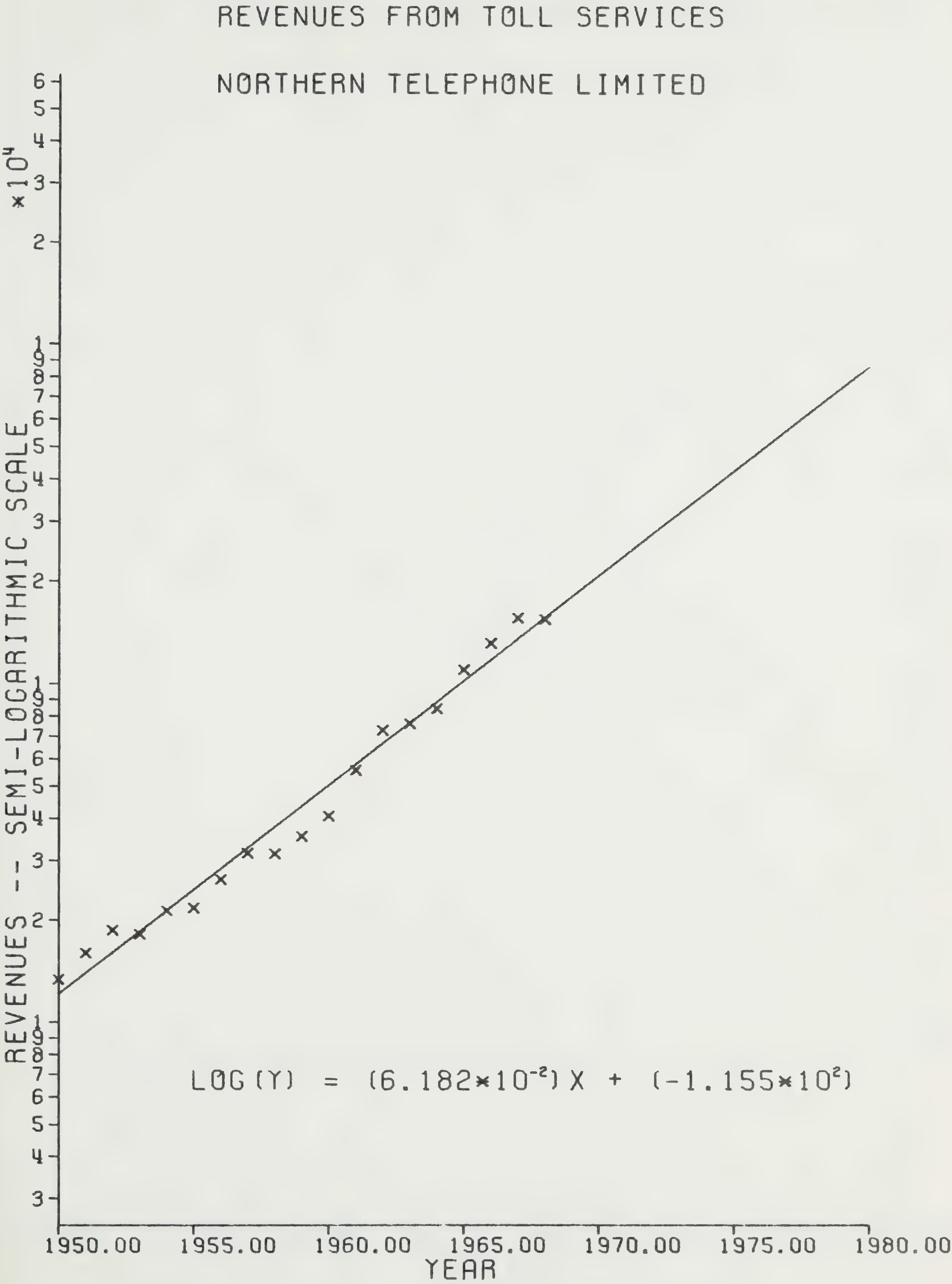
REVENUES FROM TOLL SERVICES

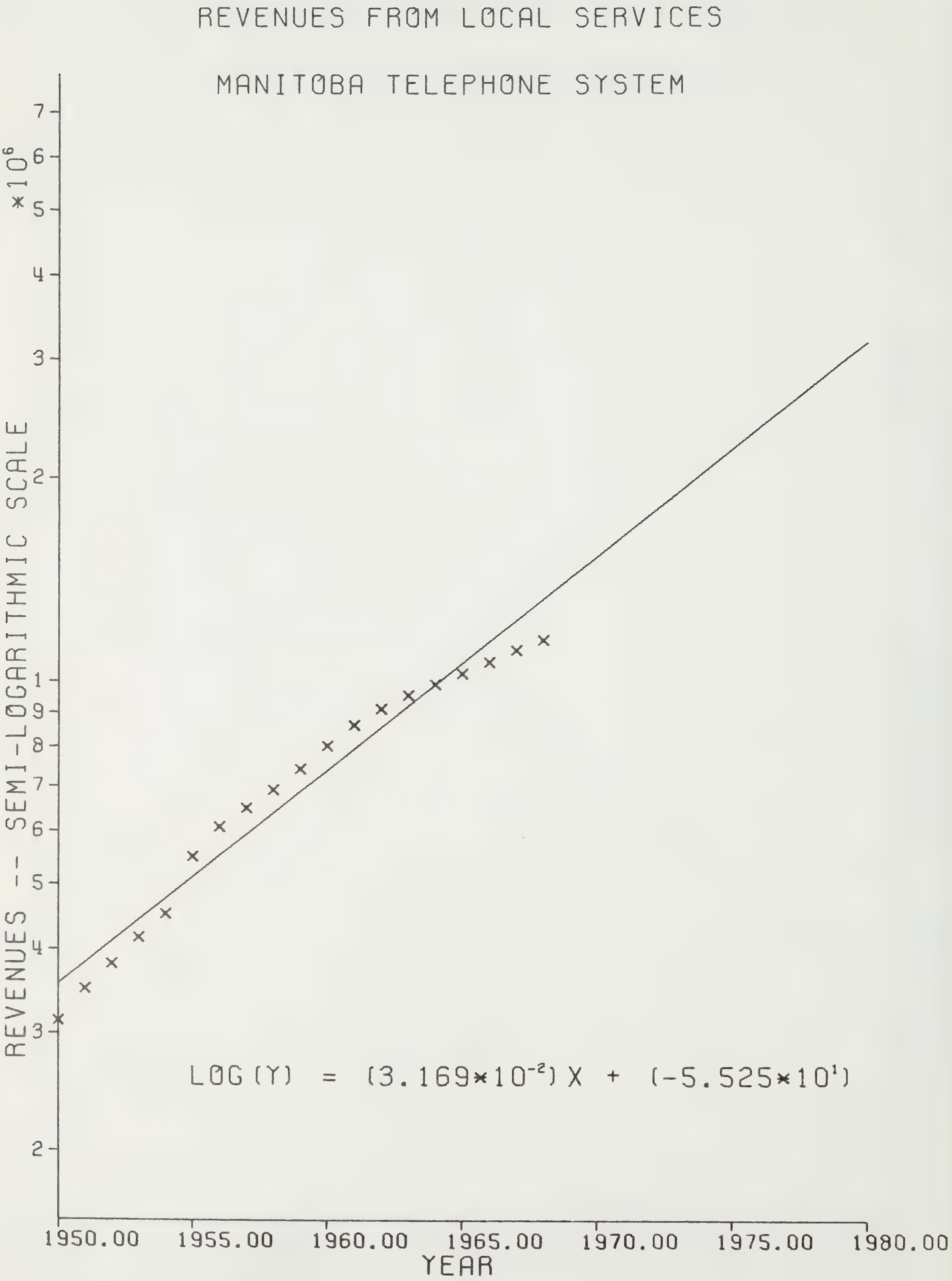


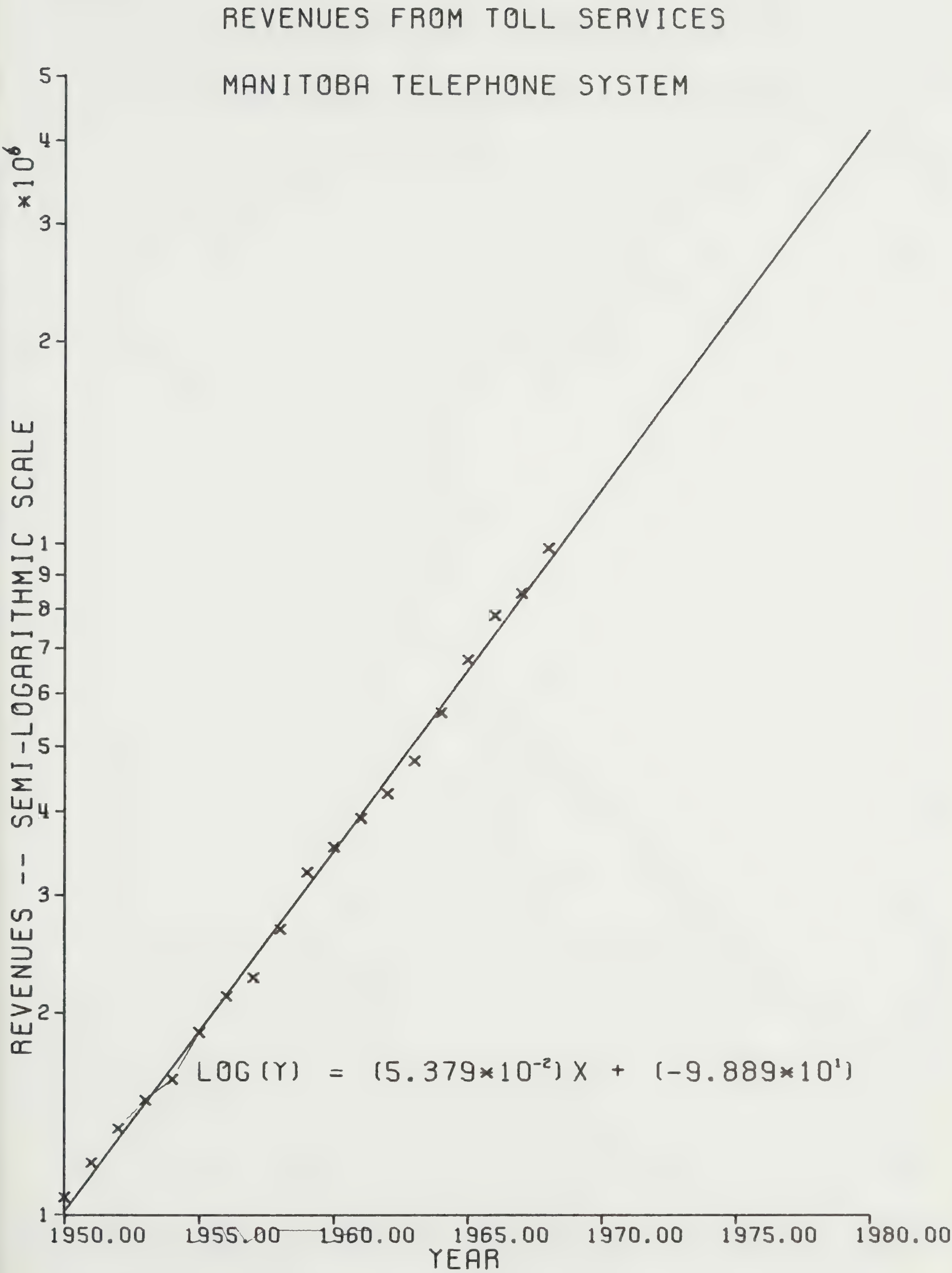

REVENUES FROM LOCAL SERVICES
QUEBEC TELEPHONE
REVENUES -- SEMI-LOGARITHMIC SCALE
*10^4
LOG(Y) = (6.908*10^-2) X + (-1.293*10^2)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

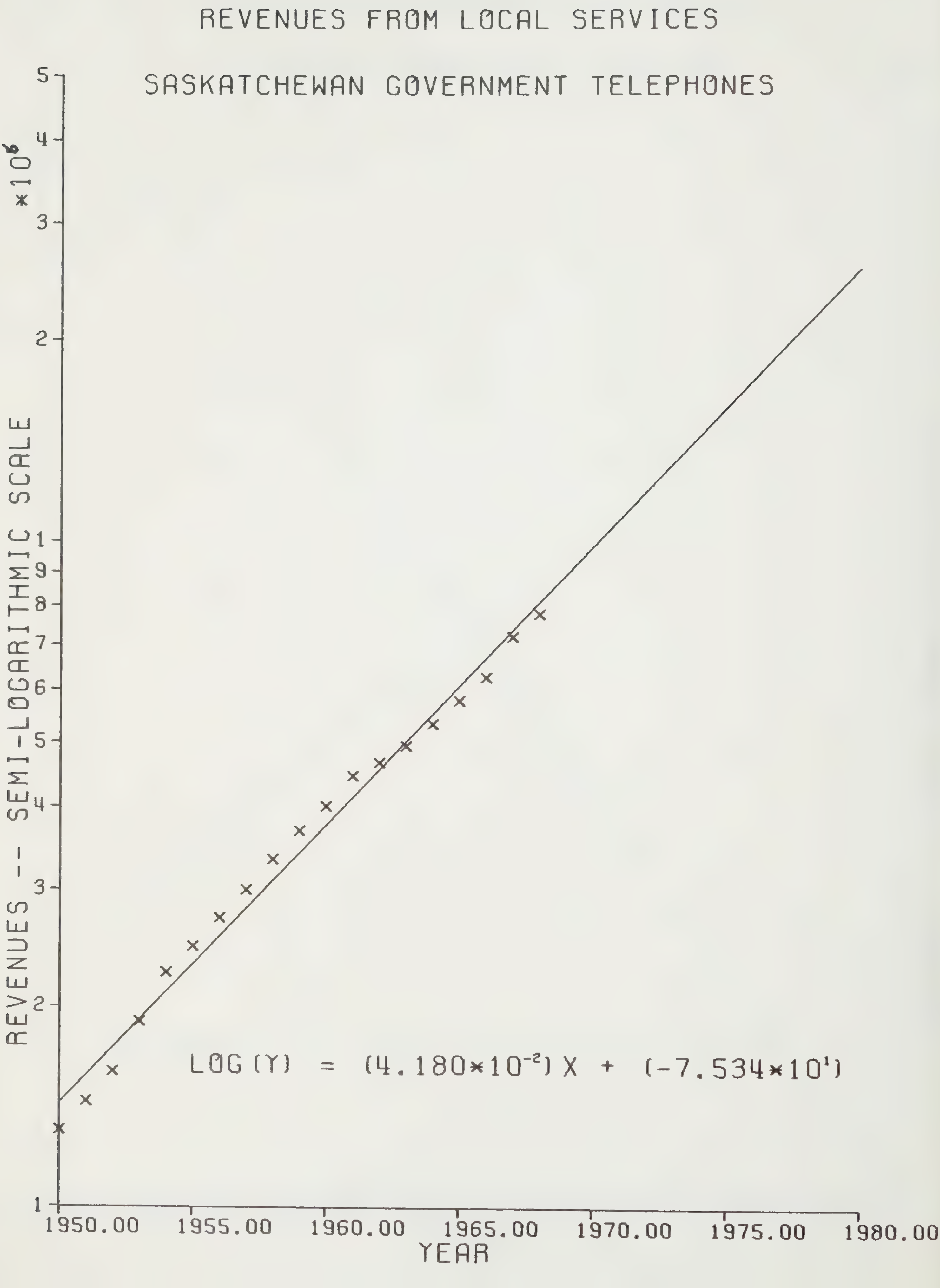

REVENUES FROM TOLL SERVICES
QUEBEC TELEPHONE
REVENUES -- SEMI-LOGARITHMIC SCALE
*10^5
LOG(Y) = (6.562*10^-2) X + (-1.223*10^2)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

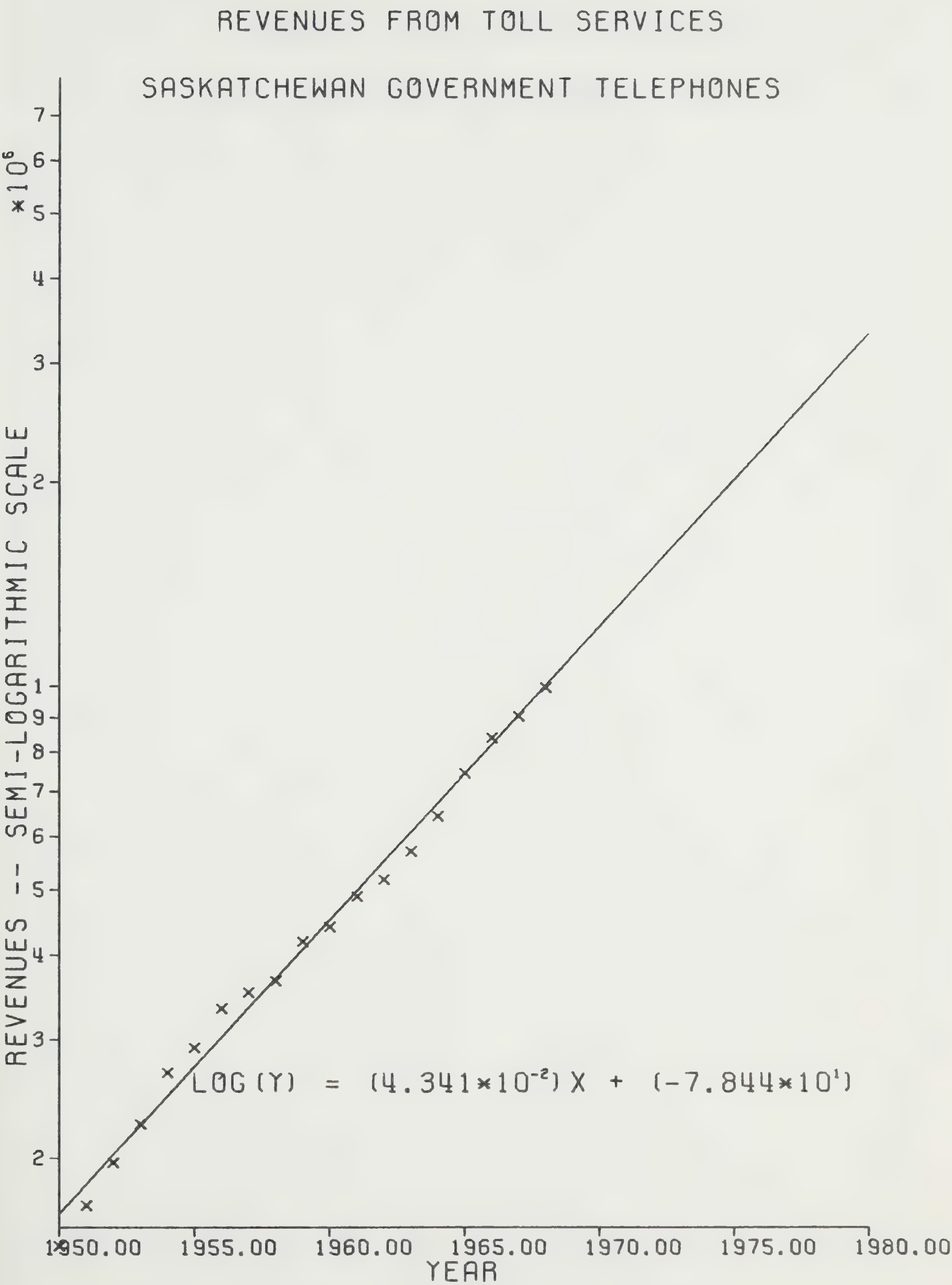

REVENUES FROM LOCAL SERVICES
NORTHERN TELEPHONE LIMITED
REVENUES -- SEMI-LOGARITHMIC SCALE
*10^5
1
9
8
7
6
5
4
3
2
1
9
8
7
6
5
4
3
LOG(Y) = (4.540*10^-2) X + (-8.295*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

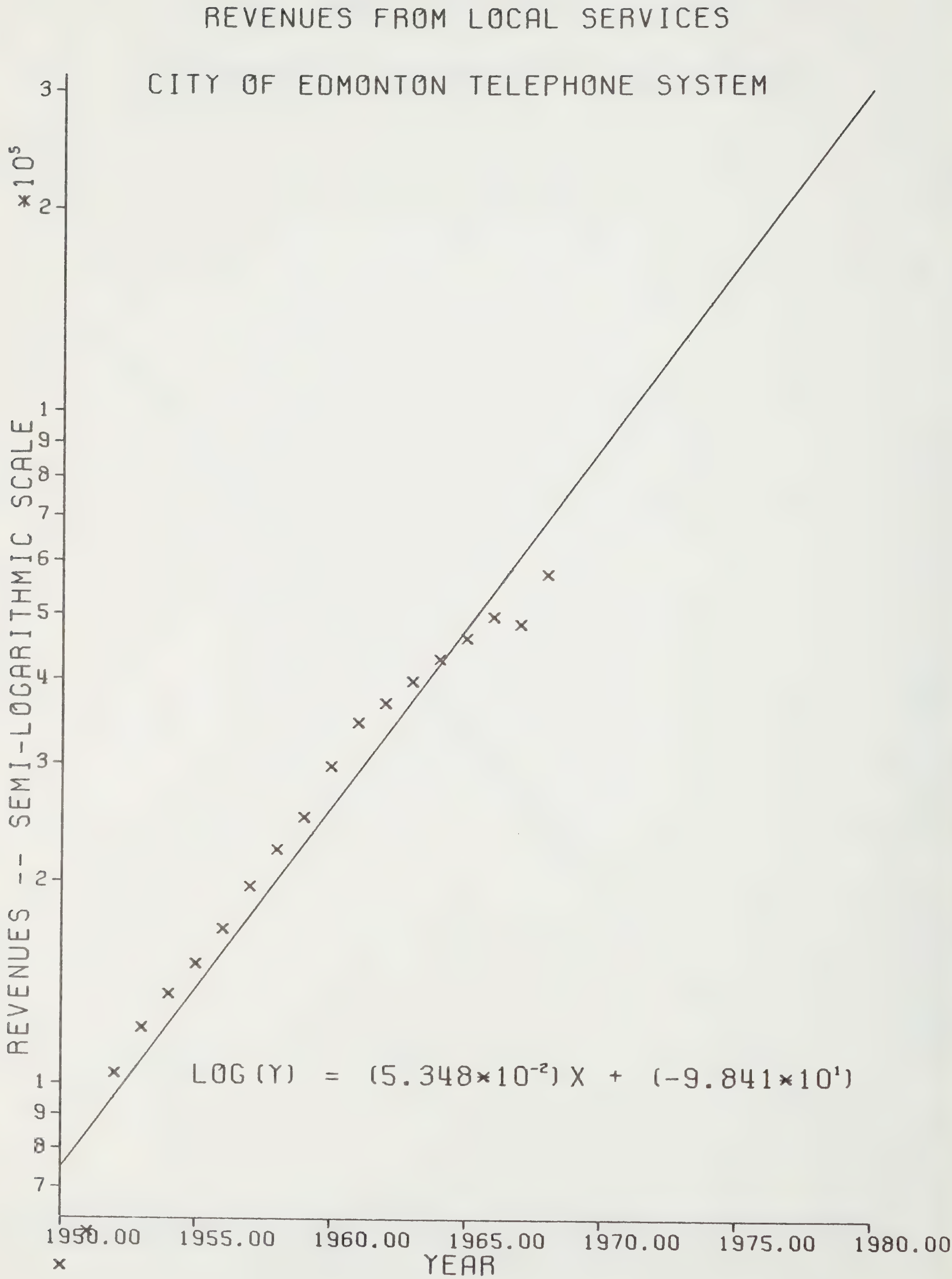

REVENUES FROM TOLL SERVICES
NORTHERN TELEPHONE LIMITED
REVENUES -- SEMI-LOGARITHMIC SCALE
×10⁴
LOG(Y) = (6.182×10⁻²) X + (-1.155×10²)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

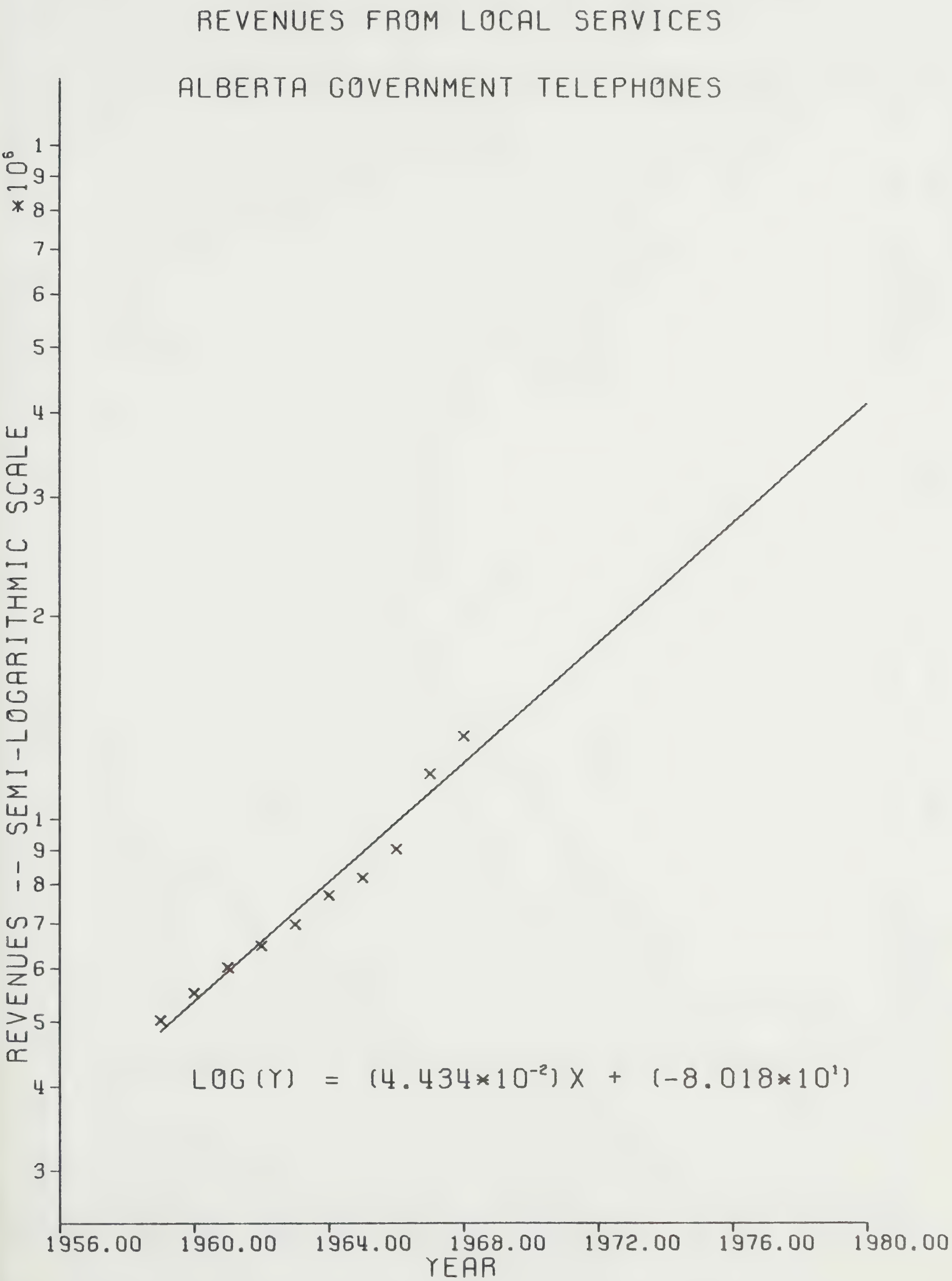

REVENUES FROM LOCAL SERVICES
MANITOBA TELEPHONE SYSTEM
REVENUES -- SEMI-LOGARITHMIC SCALE
*10^6
LOG(Y) = (3.169*10^-2) X + (-5.525*10^1)
YEAR
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00

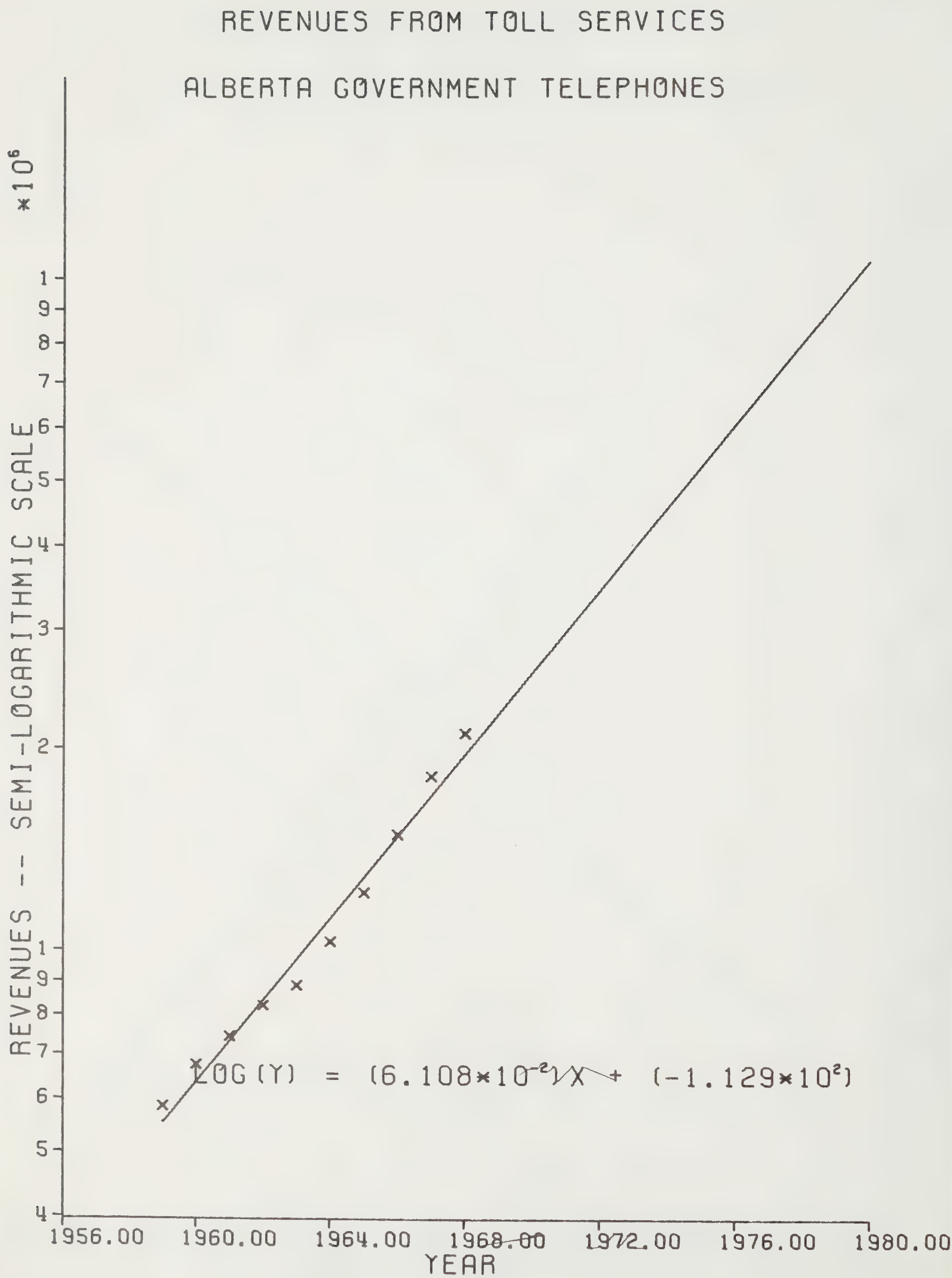

REVENUES FROM TOLL SERVICES
MANITOBA TELEPHONE SYSTEM
REVENUES -- SEMI-LOGARITHMIC SCALE
*10^6
5
4
3
2
1
9
8
7
6
5
4
3
2
1
LOG(Y) = (5.379*10^-2) X + (-9.889*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

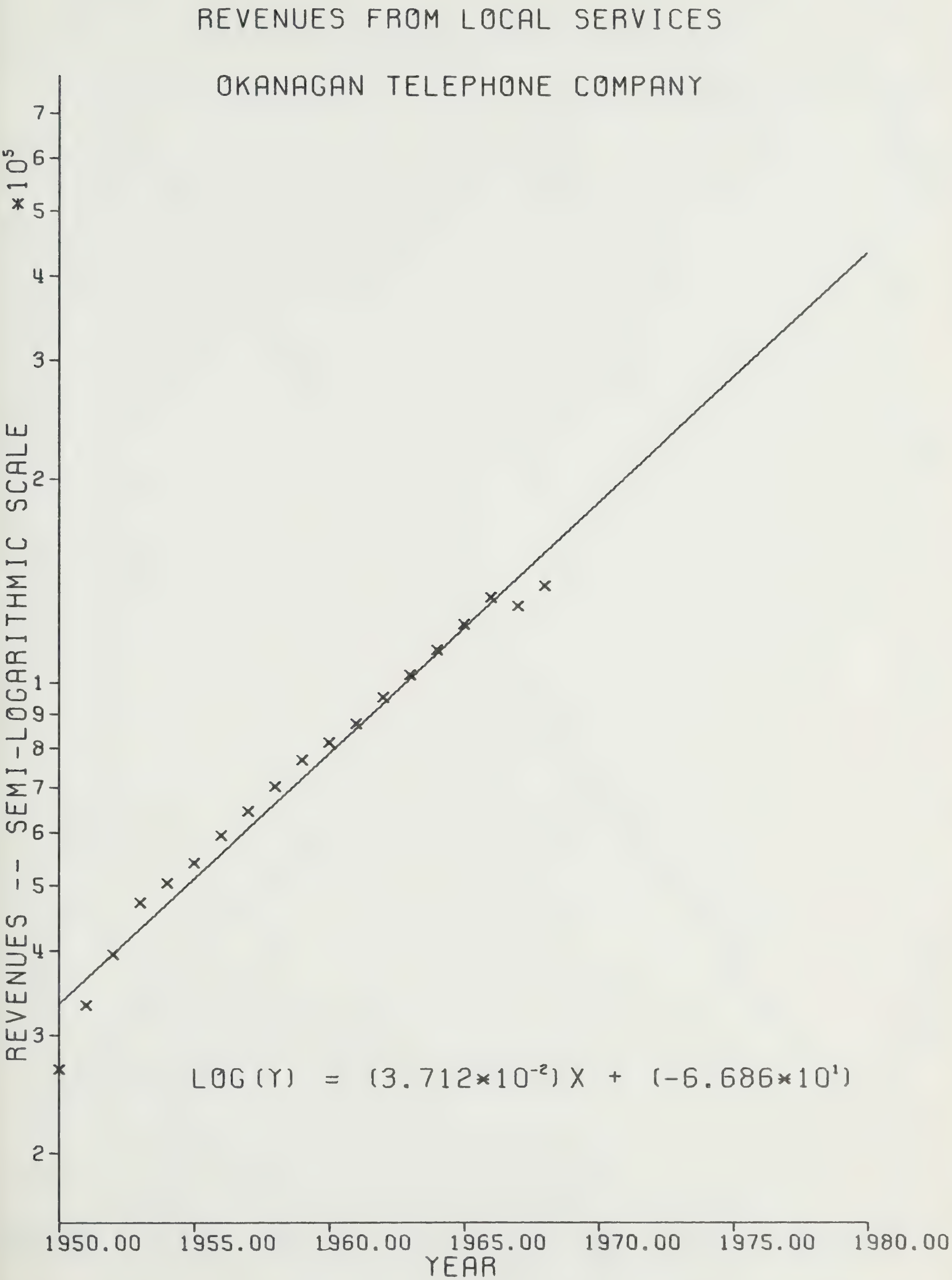

REVENUES FROM LOCAL SERVICES
SASKATCHEWAN GOVERNMENT TELEPHONES
REVENUES -- SEMI-LOGARITHMIC SCALE *10^6
LOG(Y) = (4.180*10^-2) X + (-7.534*10^1)
YEAR
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00

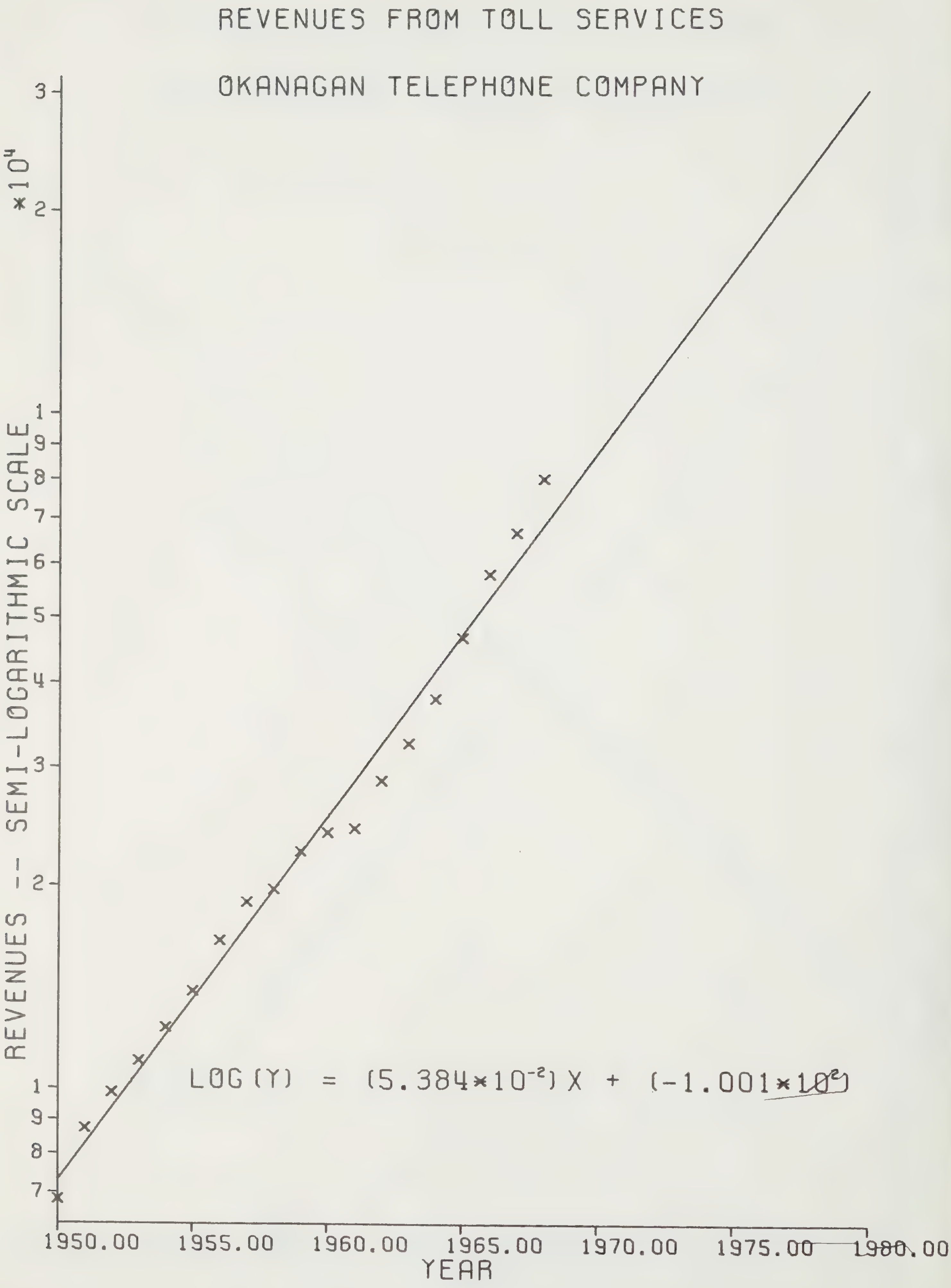

REVENUES FROM TOLL SERVICES
SASKATCHEWAN GOVERNMENT TELEPHONES
REVENUES -- SEMI-LOGARITHMIC SCALE
*10^6
LOG(Y) = (4.341*10^-2) X + (-7.844*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

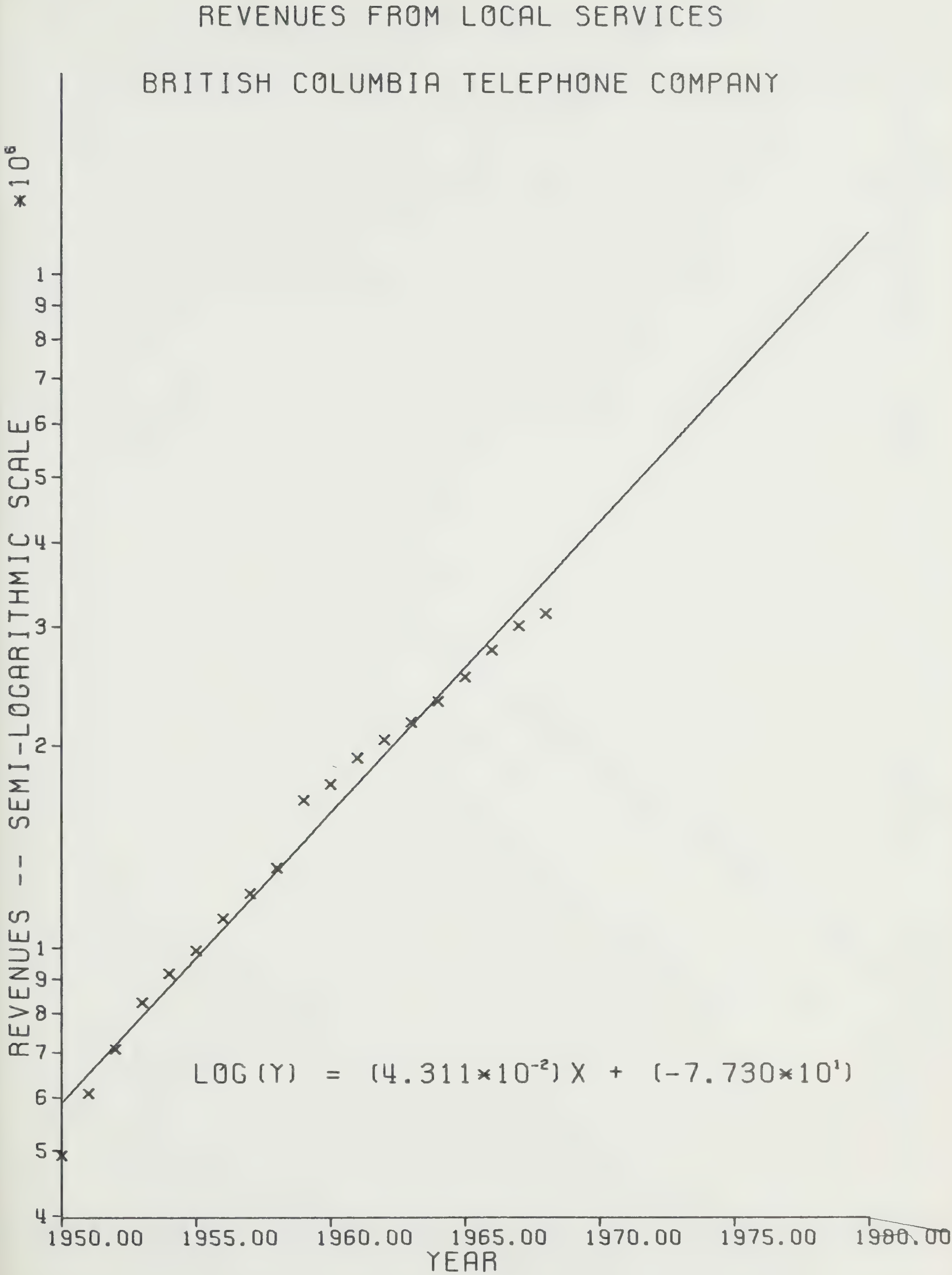

REVENUES FROM LOCAL SERVICES
CITY OF EDMONTON TELEPHONE SYSTEM
REVENUES -- SEMI-LOGARITHMIC SCALE
*10^5
LOG(Y) = (5.348*10^-2) X + (-9.841*10^1)
YEAR
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00


REVENUES FROM LOCAL SERVICES
ALBERTA GOVERNMENT TELEPHONES
REVENUES -- SEMI-LOGARITHMIC SCALE *10^6
LOG(Y) = (4.434*10^-2) X + (-8.018*10^1)
1956.00
1960.00
1964.00
1968.00
1972.00
1976.00
1980.00
YEAR

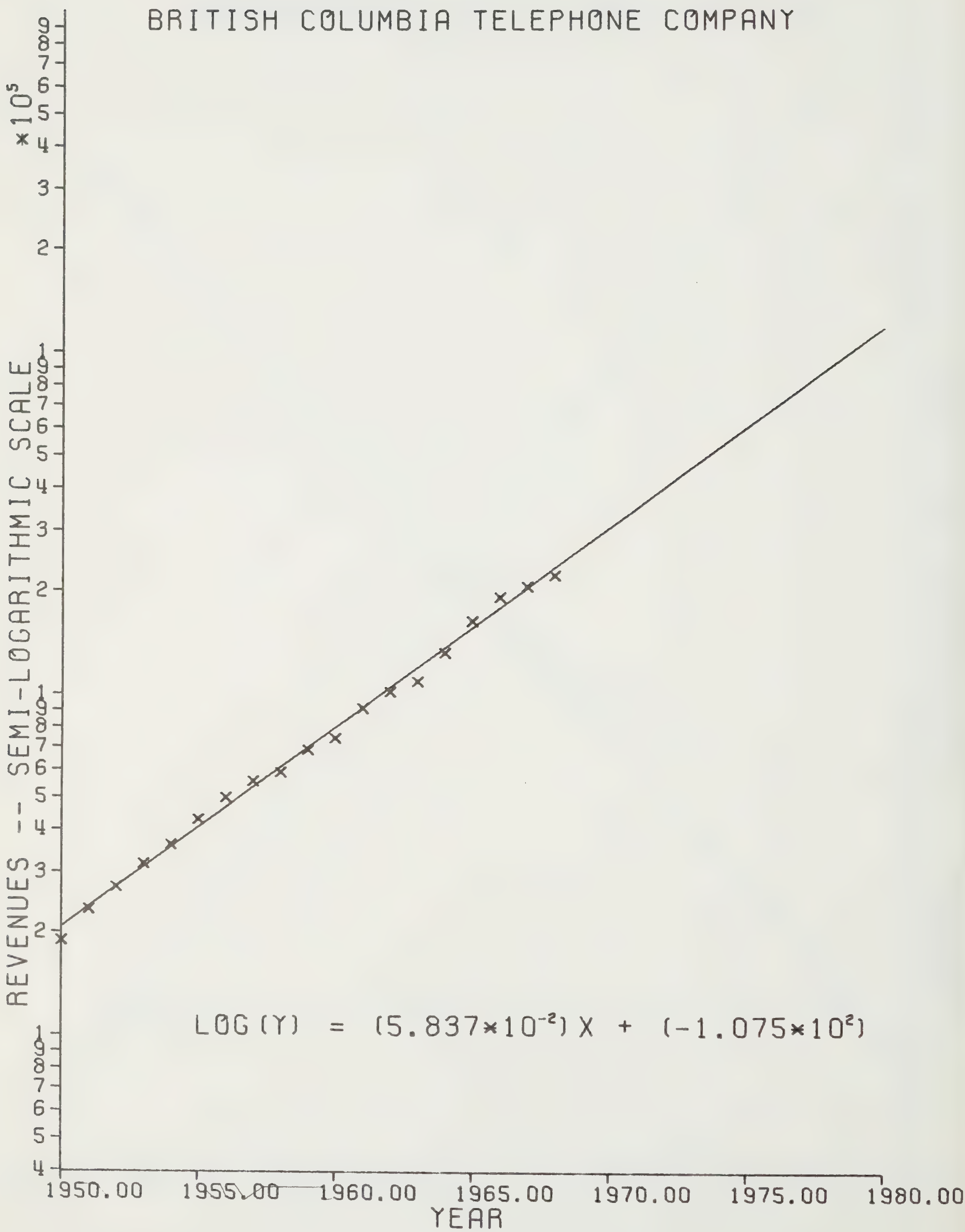

REVENUES FROM TOLL SERVICES
ALBERTA GOVERNMENT TELEPHONES
REVENUES -- SEMI-LOGARITHMIC SCALE *10⁶
LOG(Y) = (6.108*10⁻²)X + (-1.129*10²)
1956.00
1960.00
1964.00
1968.00
1972.00
1976.00
1980.00
YEAR


REVENUES FROM LOCAL SERVICES
OKANAGAN TELEPHONE COMPANY
*10^5
REVENUES -- SEMI-LOGARITHMIC SCALE
7
6
5
4
3
2
1
9
8
7
6
5
4
3
2
LOG(Y) = (3.712*10^-2) X + (-6.686*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR


REVENUES FROM TOLL SERVICES
OKANAGAN TELEPHONE COMPANY
REVENUES -- SEMI-LOGARITHMIC SCALE
*10^4
3
2
1
9
8
7
6
5
4
3
2
1
9
8
7
LOG(Y) = (5.384*10^-2) X + (-1.001*10^2)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR


REVENUES FROM LOCAL SERVICES
BRITISH COLUMBIA TELEPHONE COMPANY
*10^6
REVENUES -- SEMI-LOGARITHMIC SCALE
YEAR
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
4
5
6
7
8
9
1
2
3
4
5
6
7
8
9
1
LOG(Y) = (4.311*10^-2) X + (-7.730*10^1)

REVENUES FROM TOLL SERVICES

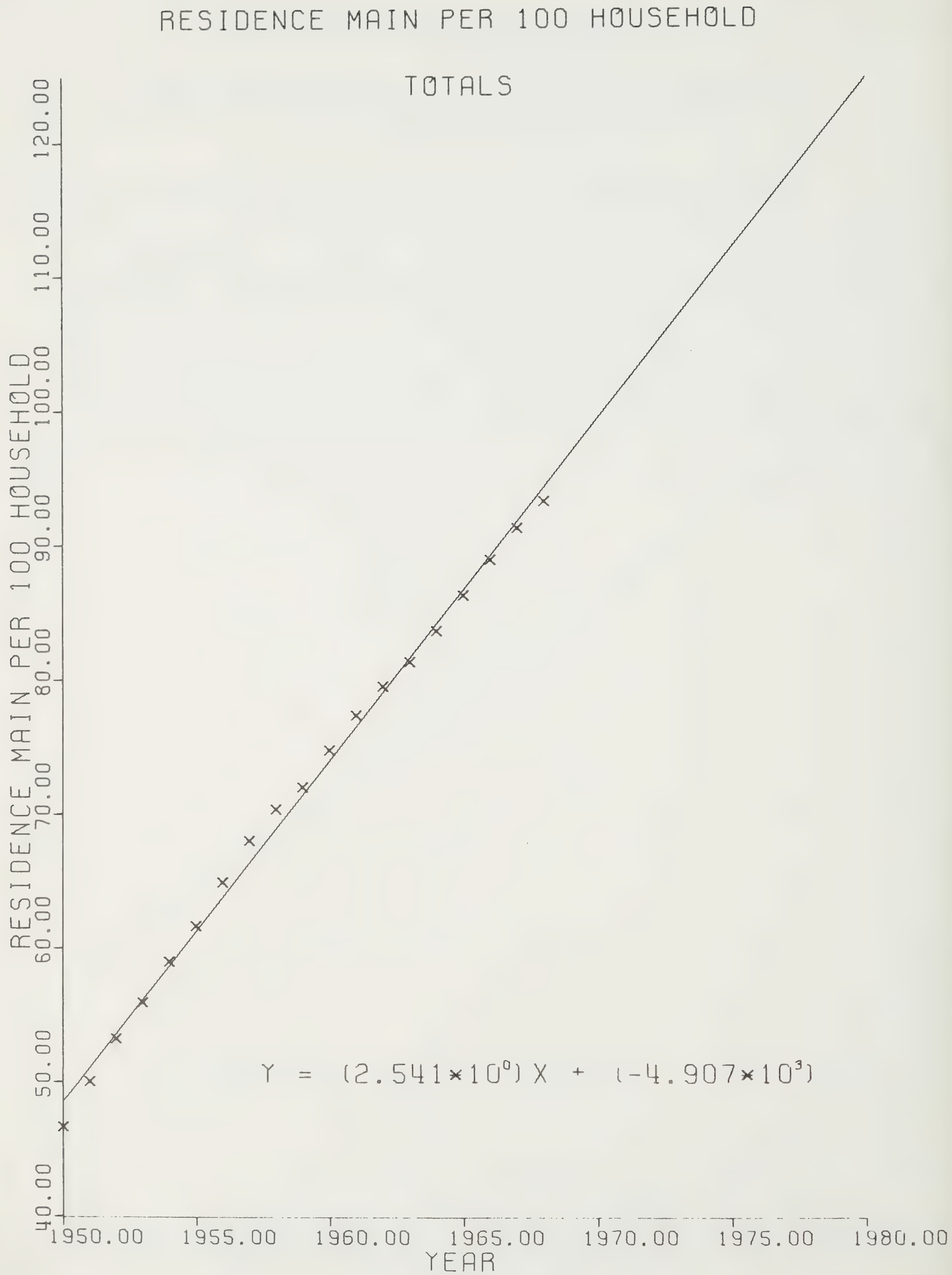


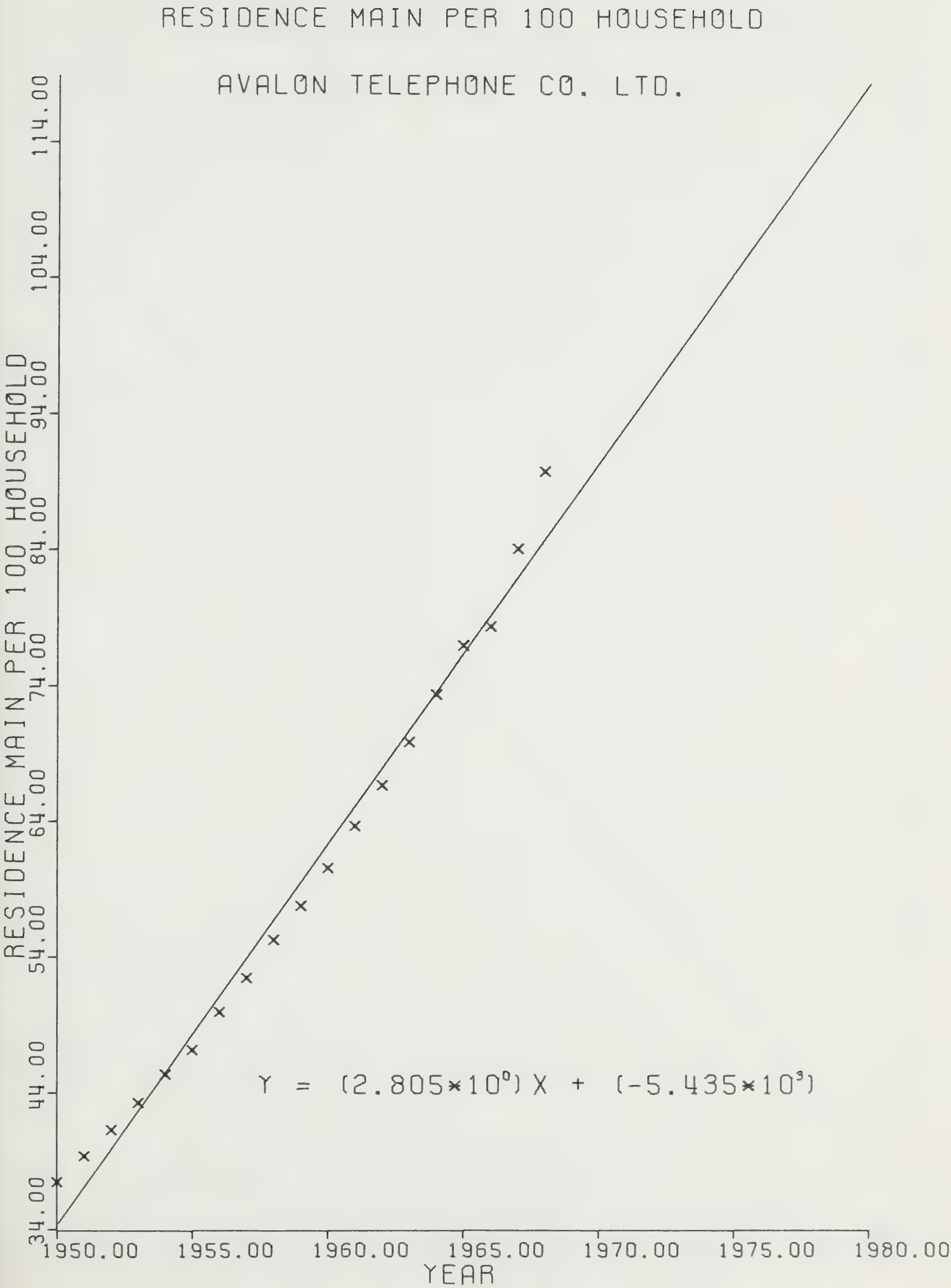
APPENDIX C.

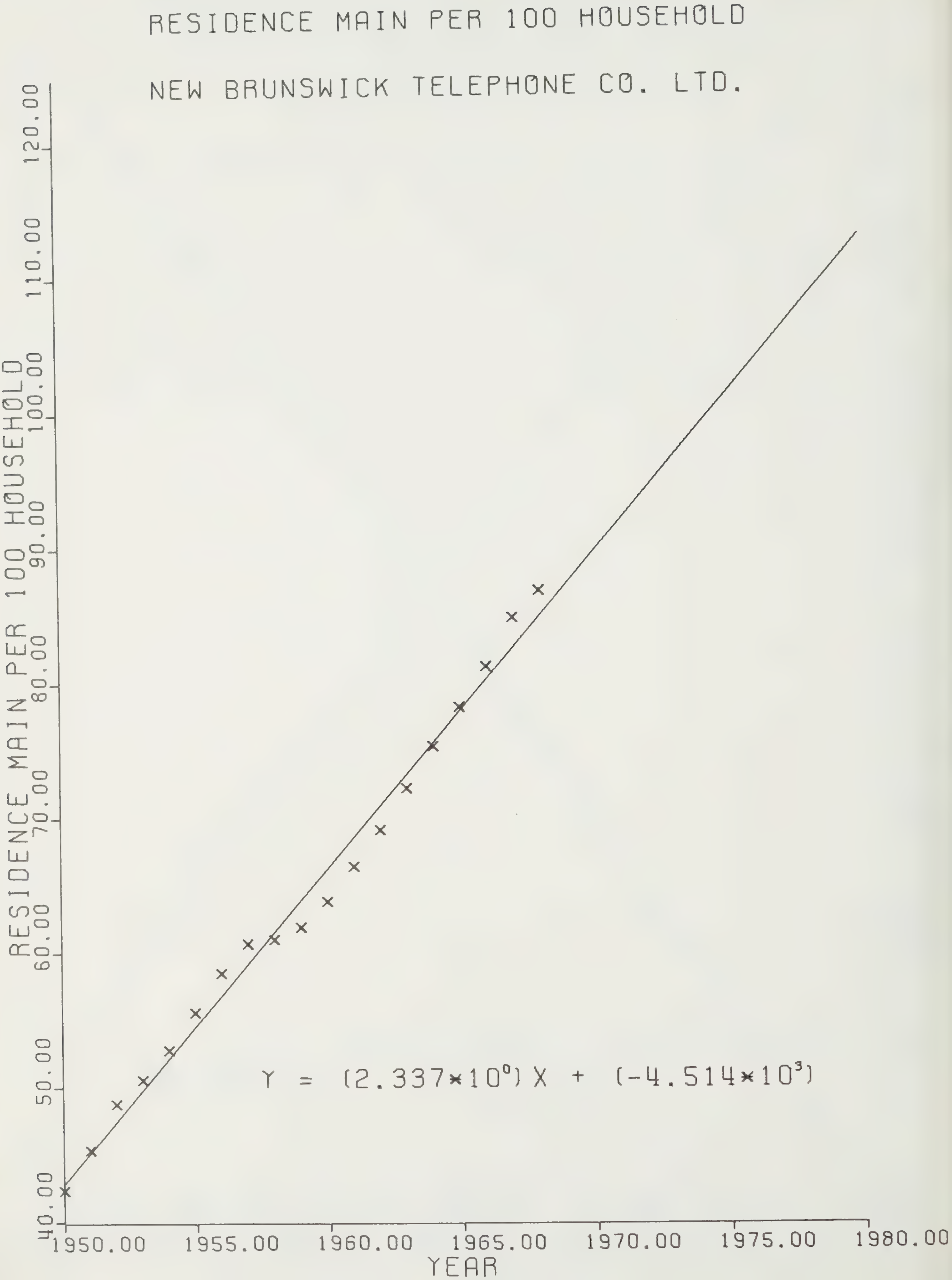
Ratio of Installations to Households

This appendix depicts graphically the secular growth in the number of telephones (residence main) per 100 households. It will be observed that in the relatively short period of eighteen years residential telephone installations increased from less than one for every two households to almost one per household.

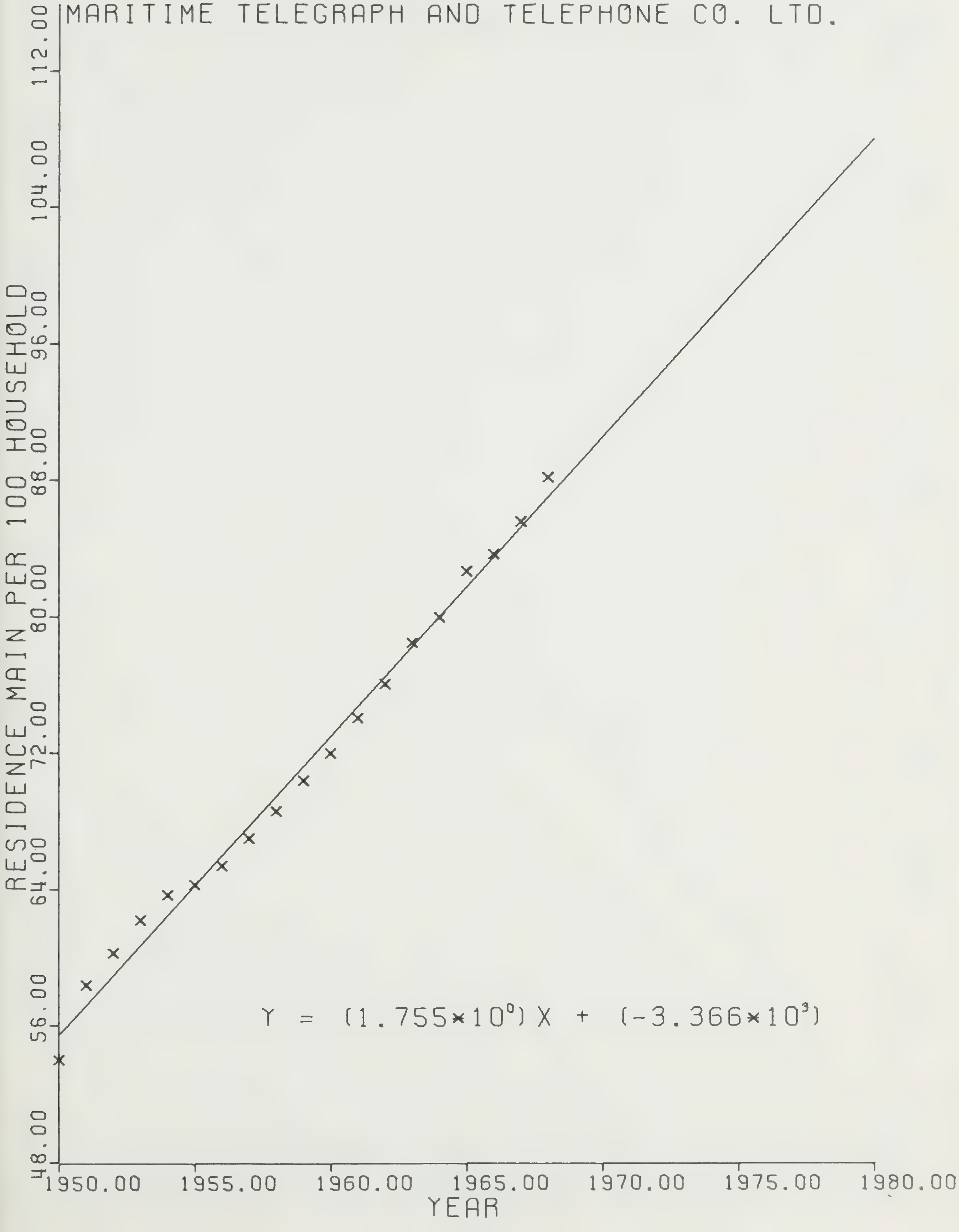
Another interesting feature of these data is the rather wide regional variation in the proportion -- a variation, in 1967 for example, from less than 0.8 to more than 0.95.

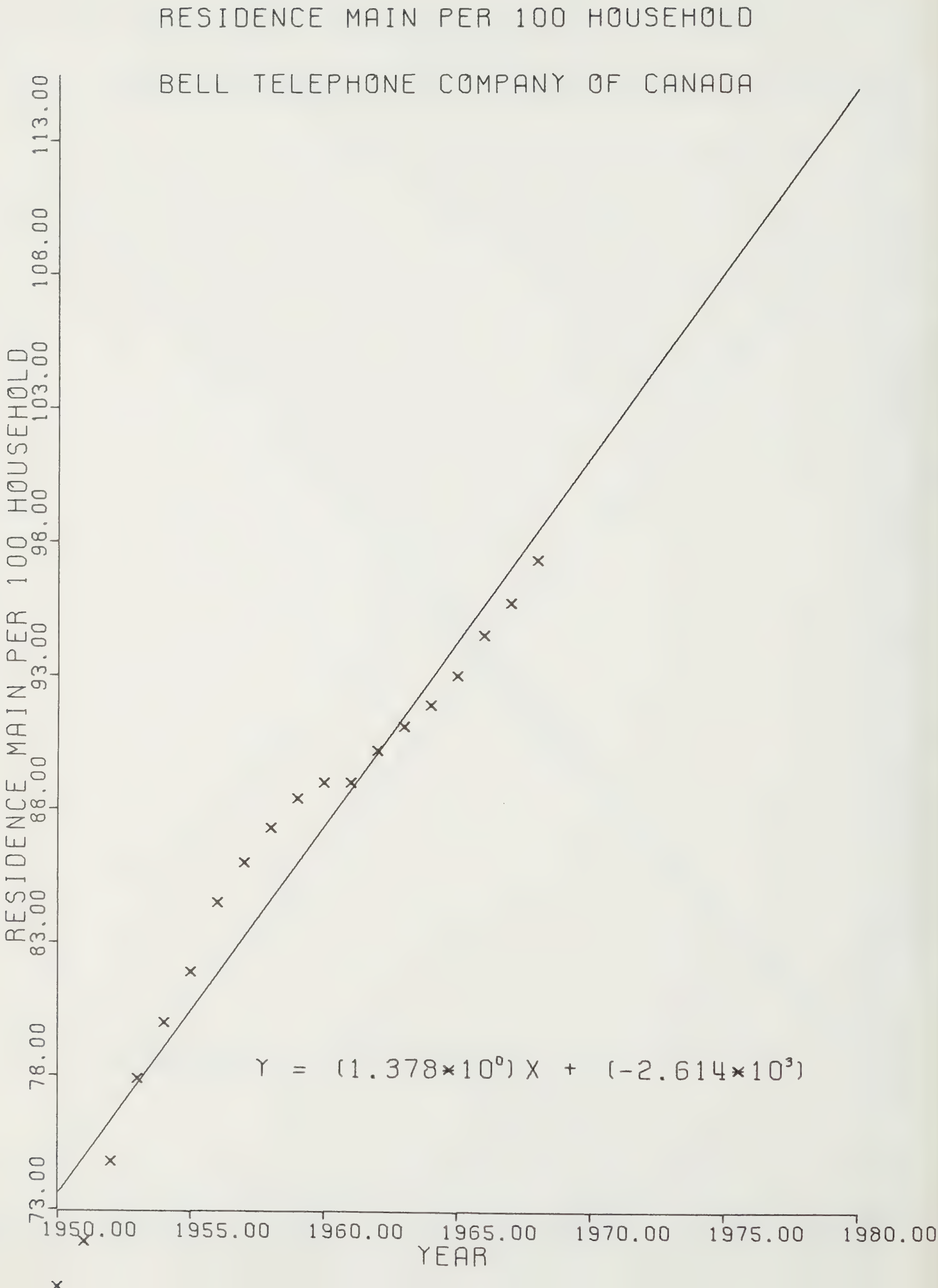

RESIDENCE MAIN PER 100 HOUSEHOLD
TOTALS
RESIDENCE MAIN PER 100 HOUSEHOLD
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
Y = (2.541×10⁰) X + (-4.907×10³)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR


RESIDENCE MAIN PER 100 HOUSEHOLD
AVALON TELEPHONE CO. LTD.
RESIDENCE MAIN PER 100 HOUSEHOLD
34.00
44.00
54.00
64.00
74.00
84.00
94.00
104.00
114.00
$Y = (2.805 * 10^0) X + (-5.435 * 10^3)$
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

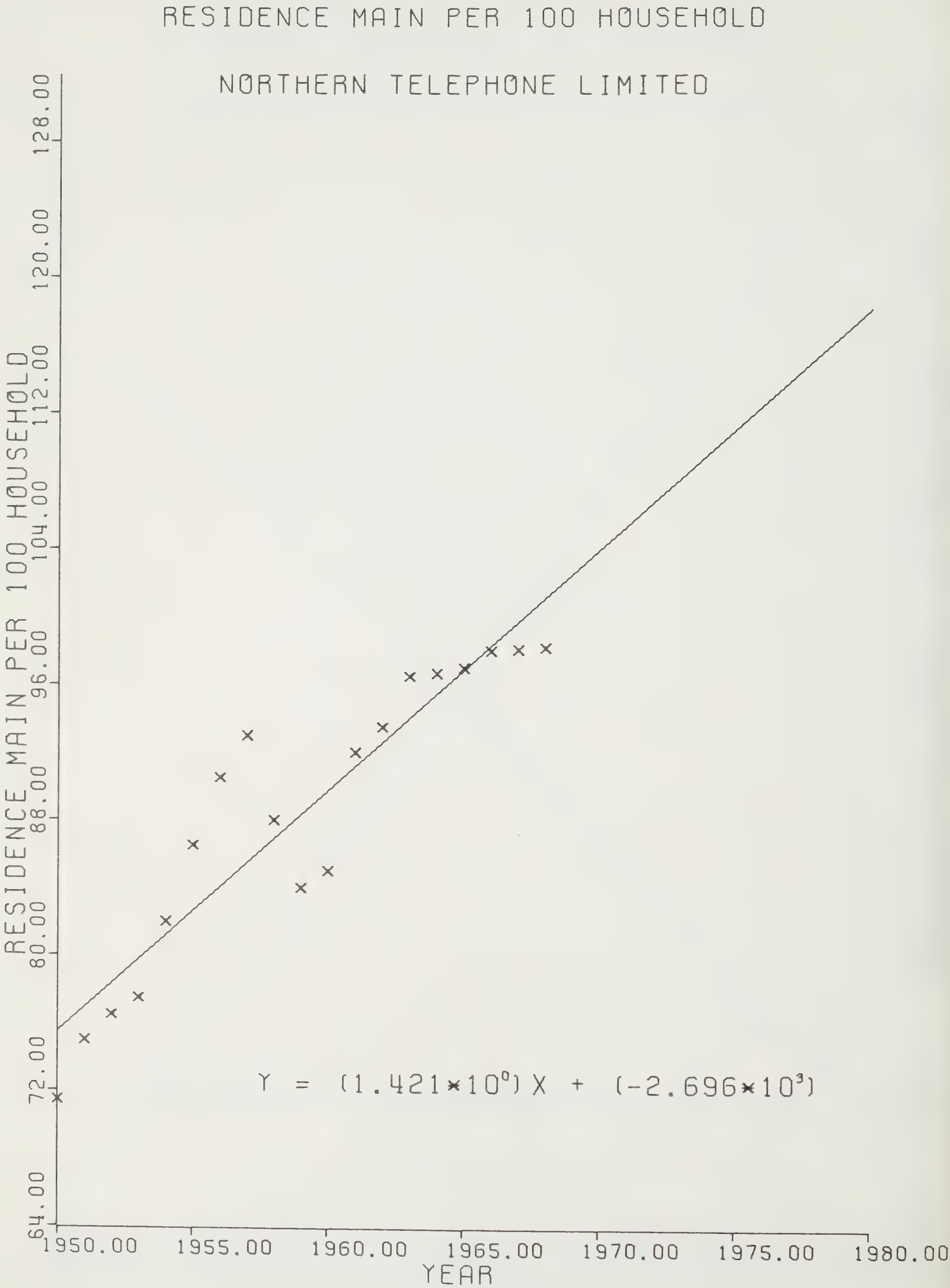

RESIDENCE MAIN PER 100 HOUSEHOLD
NEW BRUNSWICK TELEPHONE CO. LTD.
RESIDENCE MAIN PER 100 HOUSEHOLD
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
Y = (2.337*10⁰) X + (-4.514*10³)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

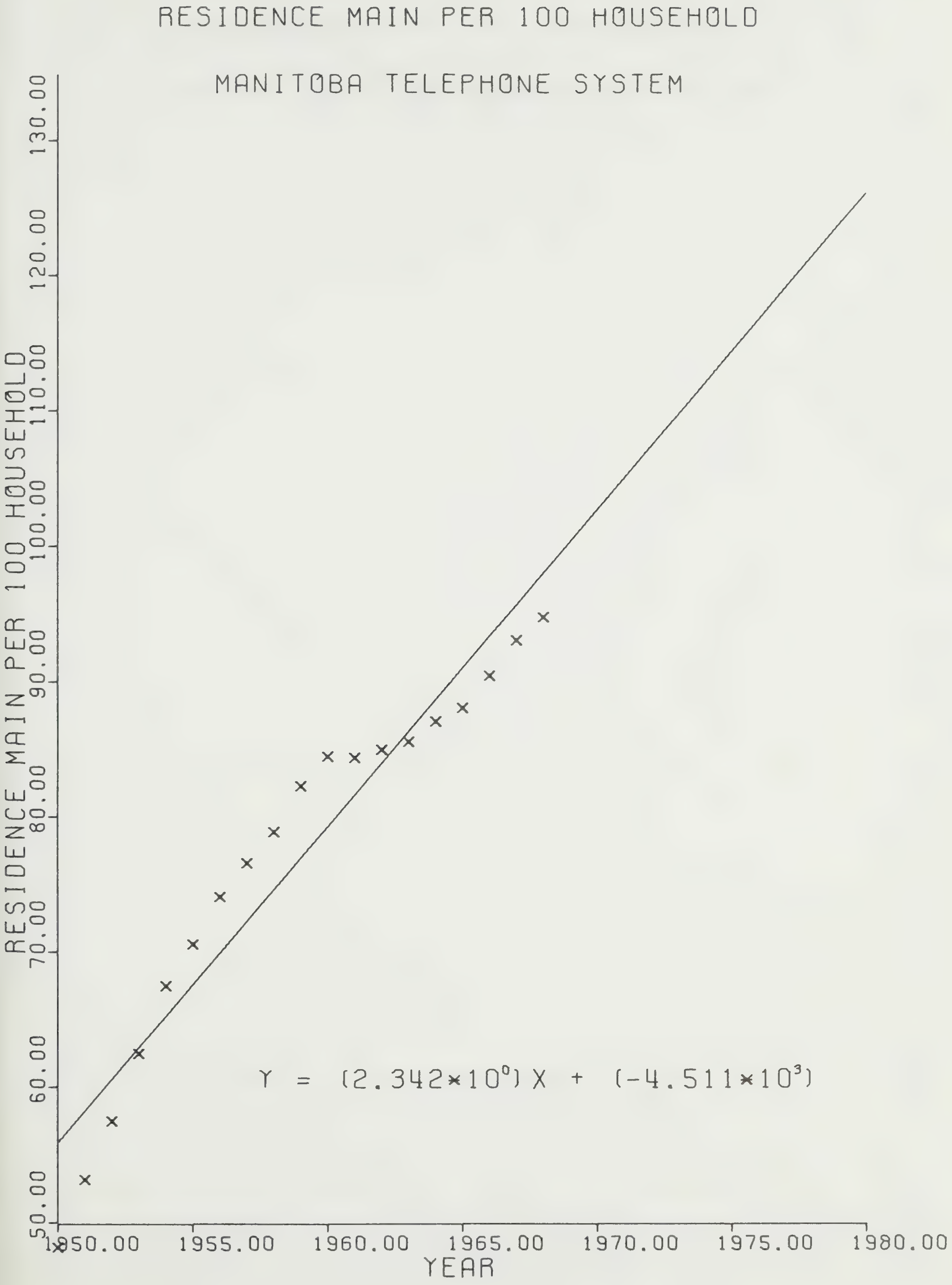
RESIDENCE MAIN PER 100 HOUSEHOLD

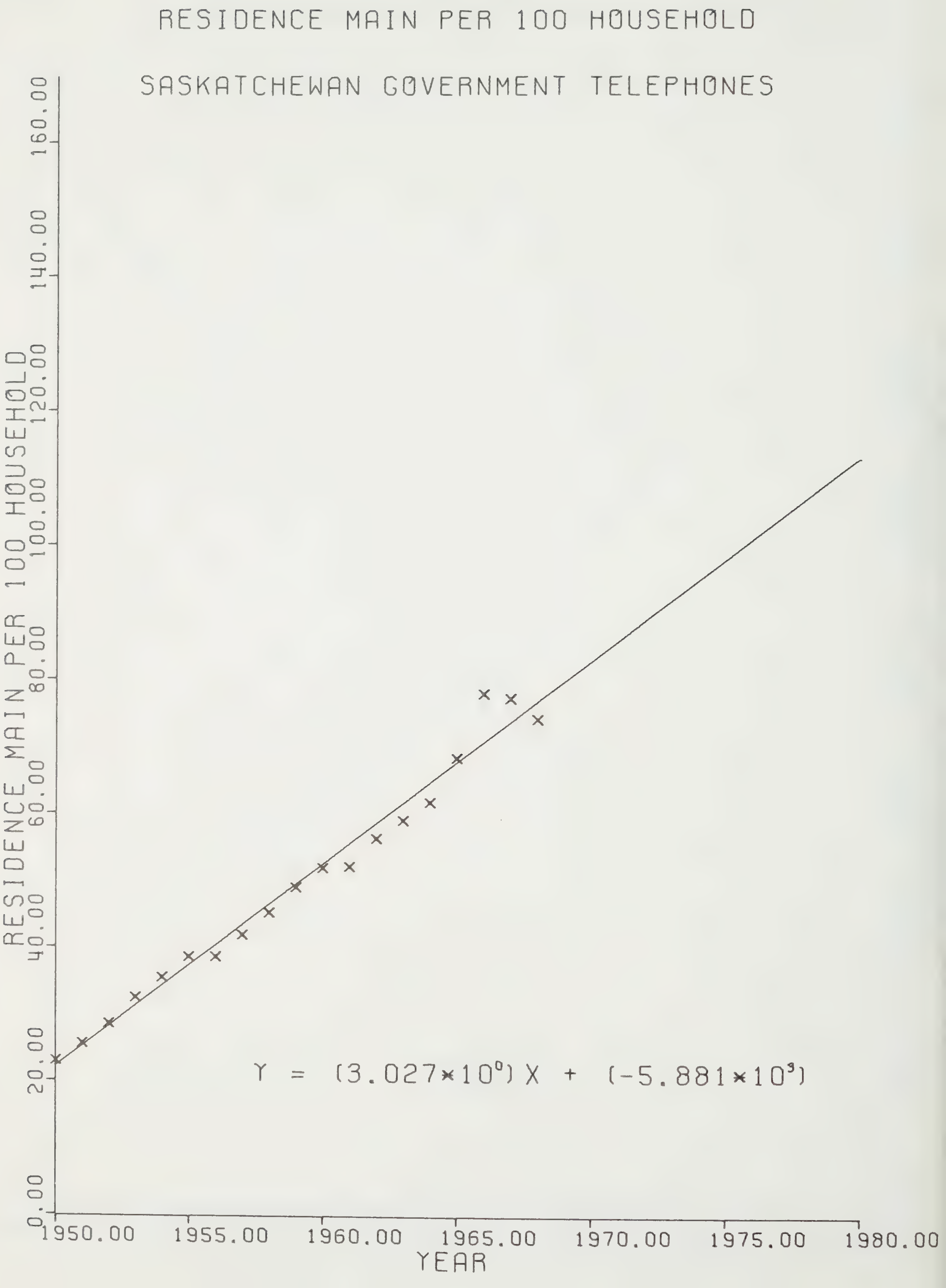


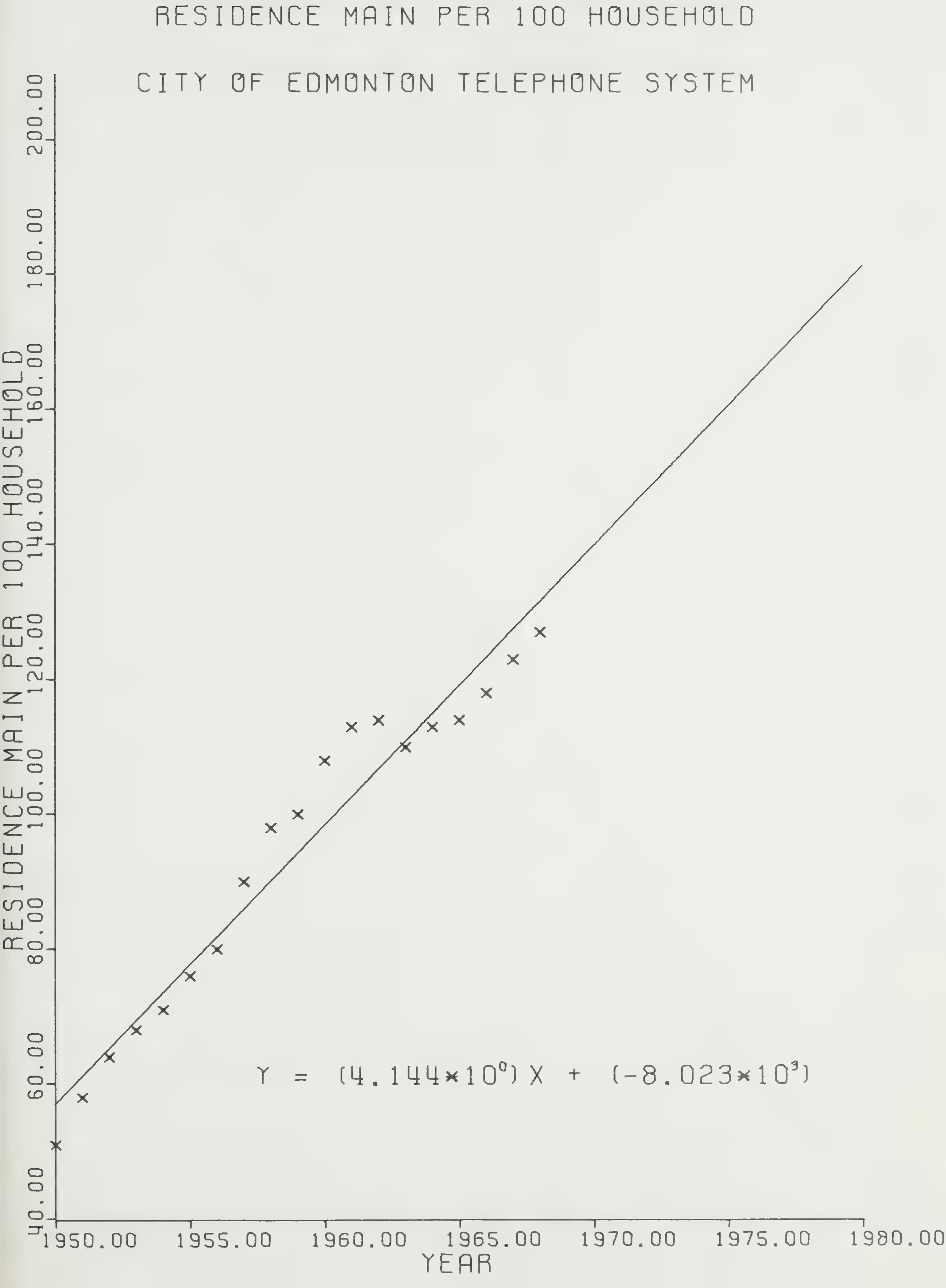

RESIDENCE MAIN PER 100 HOUSEHOLD
BELL TELEPHONE COMPANY OF CANADA
RESIDENCE MAIN PER 100 HOUSEHOLD
73.00
78.00
83.00
88.00
93.00
98.00
103.00
108.00
113.00
Y = (1.378*10⁰) X + (-2.614*10³)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

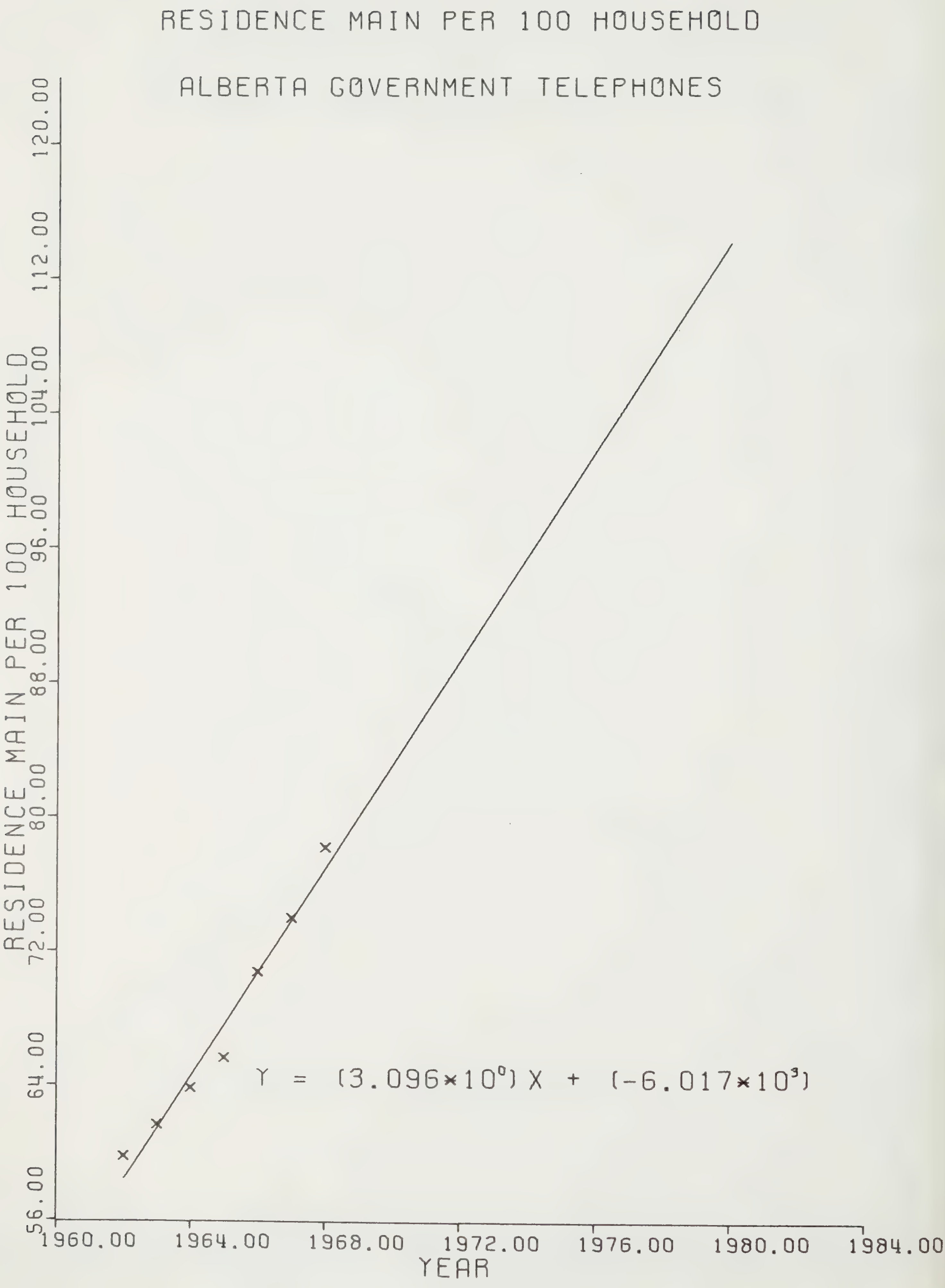

RESIDENCE MAIN PER 100 HOUSEHOLD
QUEBEC TELEPHONE
RESIDENCE MAIN PER 100 HOUSEHOLD
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR
Y = (4.030×10⁰) X + (-7.845×10³)


RESIDENCE MAIN PER 100 HOUSEHOLD
NORTHERN TELEPHONE LIMITED
RESIDENCE MAIN PER 100 HOUSEHOLD
128.00
120.00
112.00
104.00
96.00
88.00
80.00
72.00
64.00
Y = (1.421×10⁰) X + (-2.696×10³)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

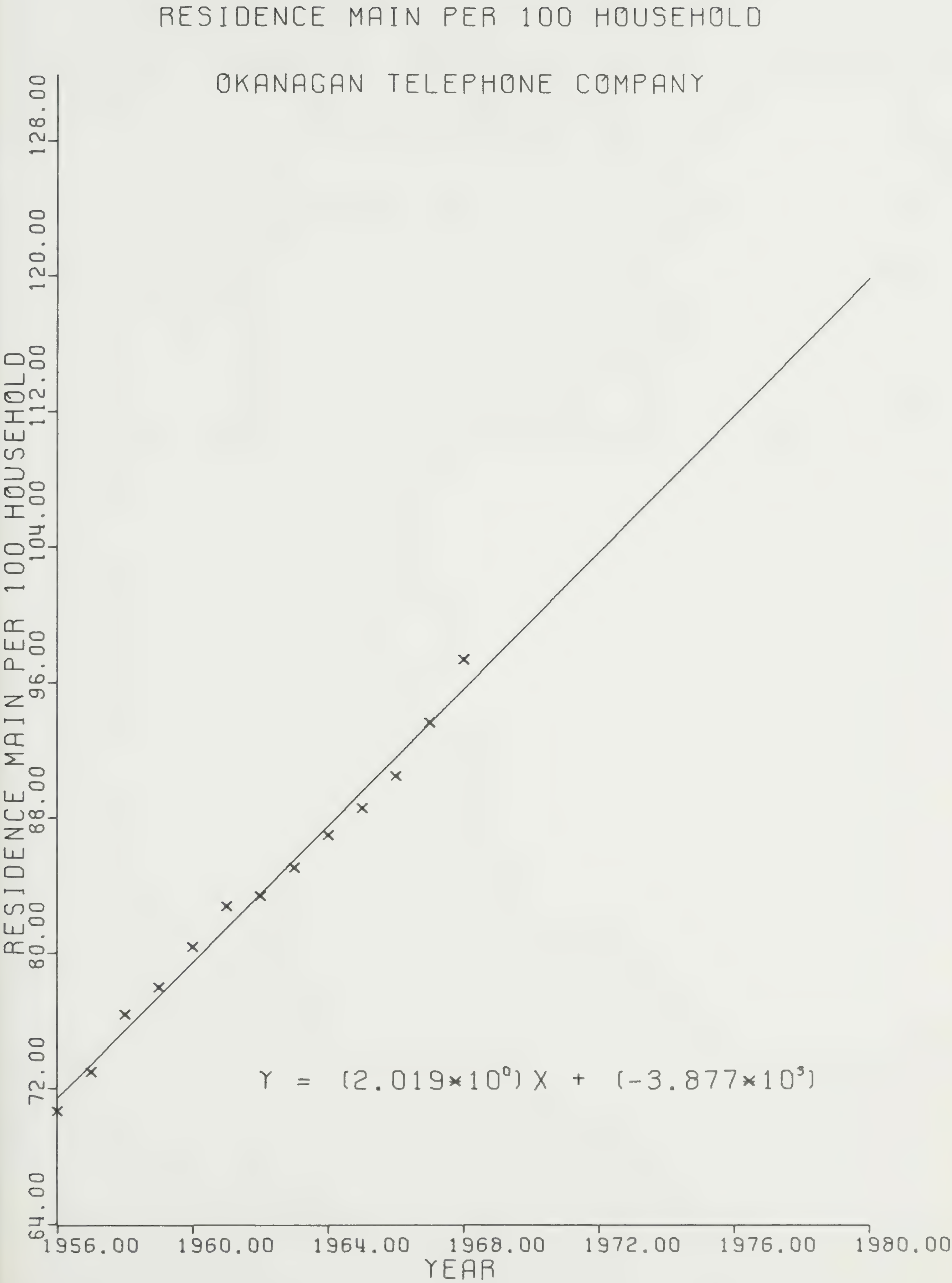

RESIDENCE MAIN PER 100 HOUSEHOLD
MANITOBA TELEPHONE SYSTEM
RESIDENCE MAIN PER 100 HOUSEHOLD
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
130.00
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR
Y = (2.342×10⁰) X + (-4.511×10³)


RESIDENCE MAIN PER 100 HOUSEHOLD
SASKATCHEWAN GOVERNMENT TELEPHONES
RESIDENCE MAIN PER 100 HOUSEHOLD
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
Y = (3.027×10⁰) X + (-5.881×10³)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR


RESIDENCE MAIN PER 100 HOUSEHOLD
CITY OF EDMONTON TELEPHONE SYSTEM
RESIDENCE MAIN PER 100 HOUSEHOLD
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR
Y = (4.144×10⁰) X + (-8.023×10³)


RESIDENCE MAIN PER 100 HOUSEHOLD
ALBERTA GOVERNMENT TELEPHONES
RESIDENCE MAIN PER 100 HOUSEHOLD
56.00
64.00
72.00
80.00
88.00
96.00
104.00
112.00
120.00
1960.00
1964.00
1968.00
1972.00
1976.00
1980.00
1984.00
YEAR
Y = (3.096×10⁰) X + (-6.017×10³)


RESIDENCE MAIN PER 100 HOUSEHOLD
BRITISH COLUMBIA TELEPHONE COMPANY
RESIDENCE MAIN PER 100 HOUSEHOLD
120.00
112.00
104.00
96.00
88.00
80.00
72.00
64.00
56.00
Y = (2.172×10⁰) X + (-4.180×10³)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

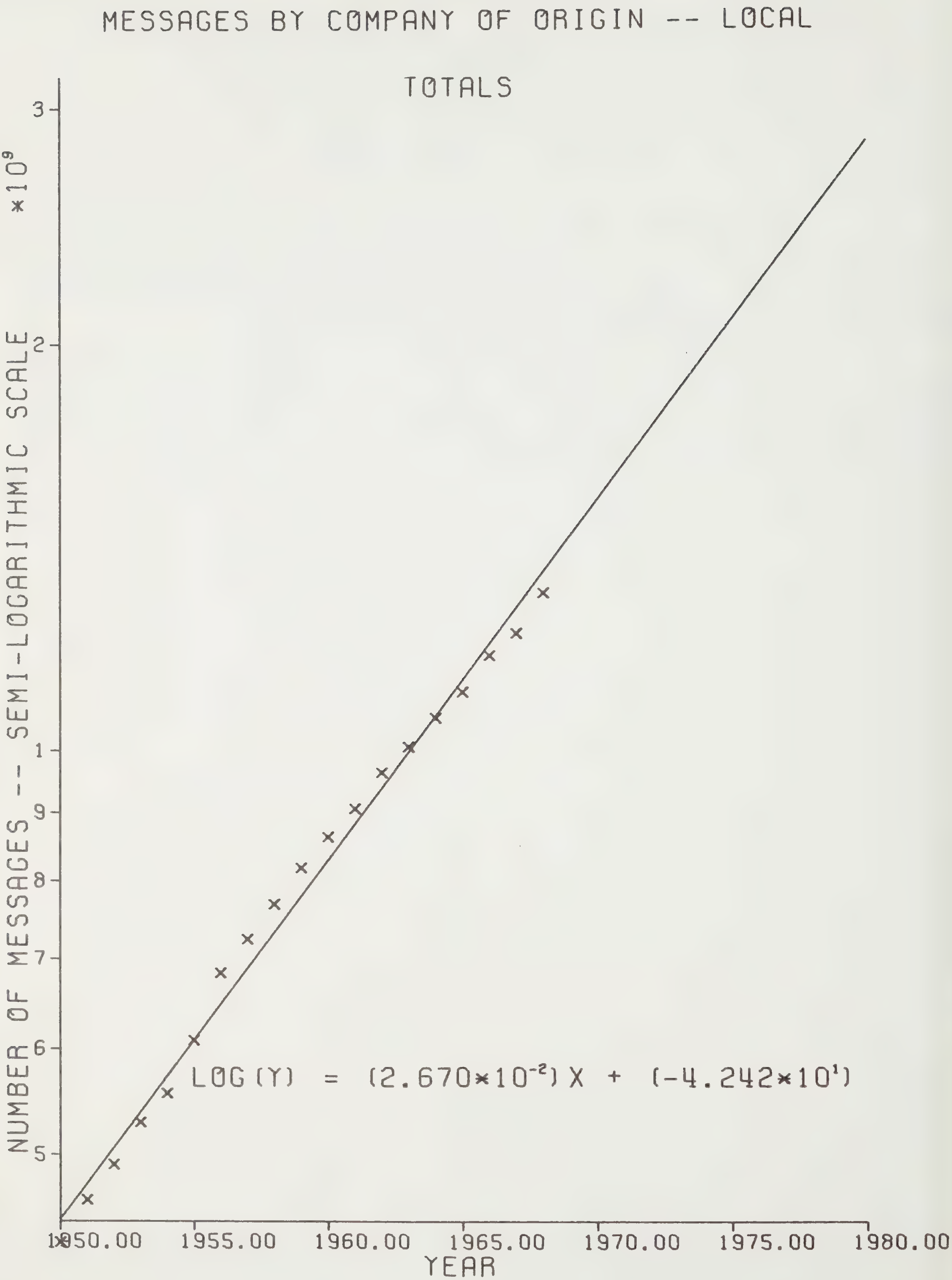

RESIDENCE MAIN PER 100 HOUSEHOLD
OKANAGAN TELEPHONE COMPANY
RESIDENCE MAIN PER 100 HOUSEHOLD
64.00
72.00
80.00
88.00
96.00
104.00
112.00
120.00
128.00
Y = (2.019×10⁰) X + (-3.877×10³)
1956.00
1960.00
1964.00
1968.00
1972.00
1976.00
1980.00
YEAR

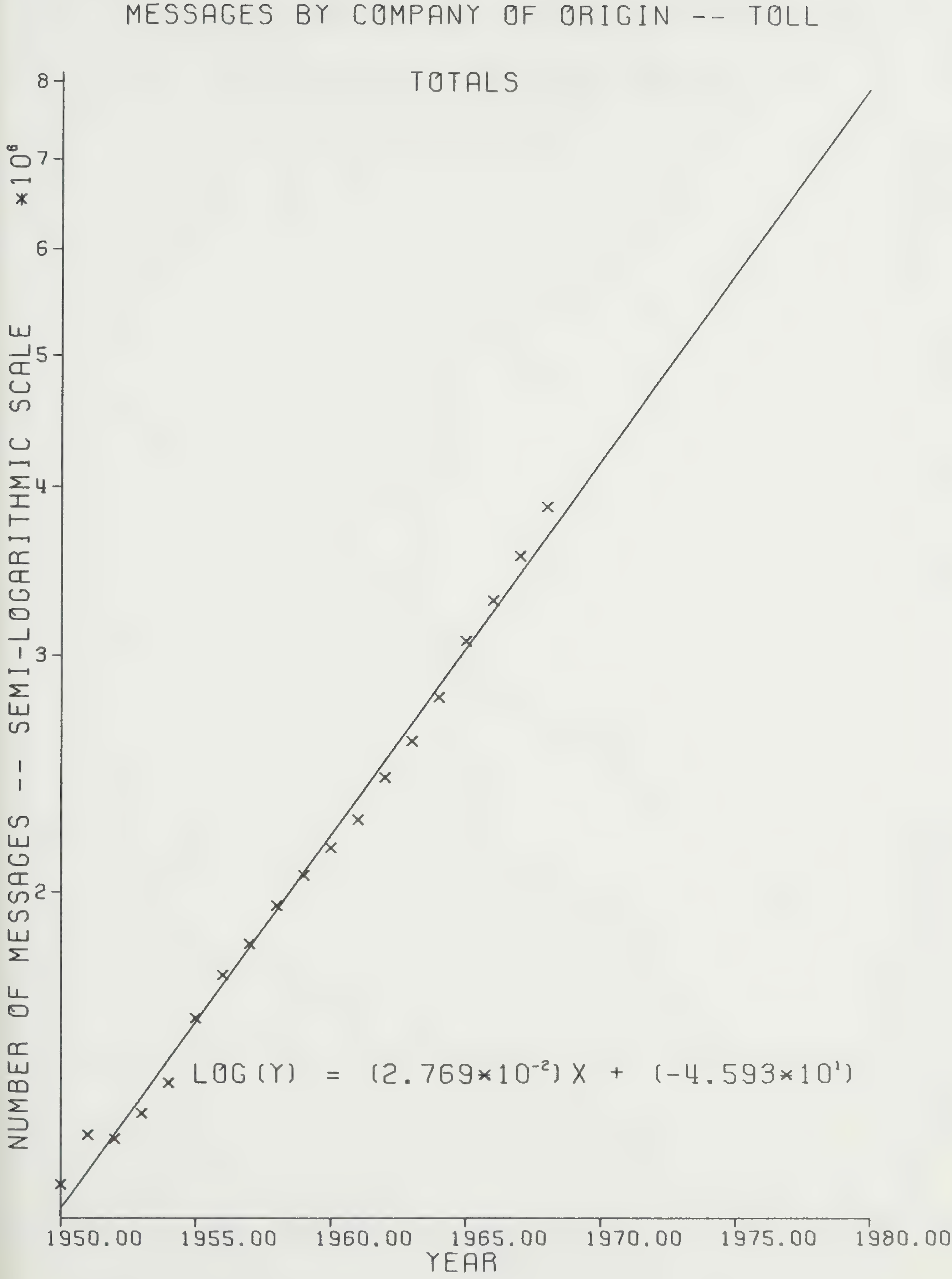
APPENDIX D.

Messages by Company of Origin

A further set of data provided by the industry was a tabulation of messages by company of origin. Unfortunately for purposes of this study, no breakdown between household and non-household messages was available.

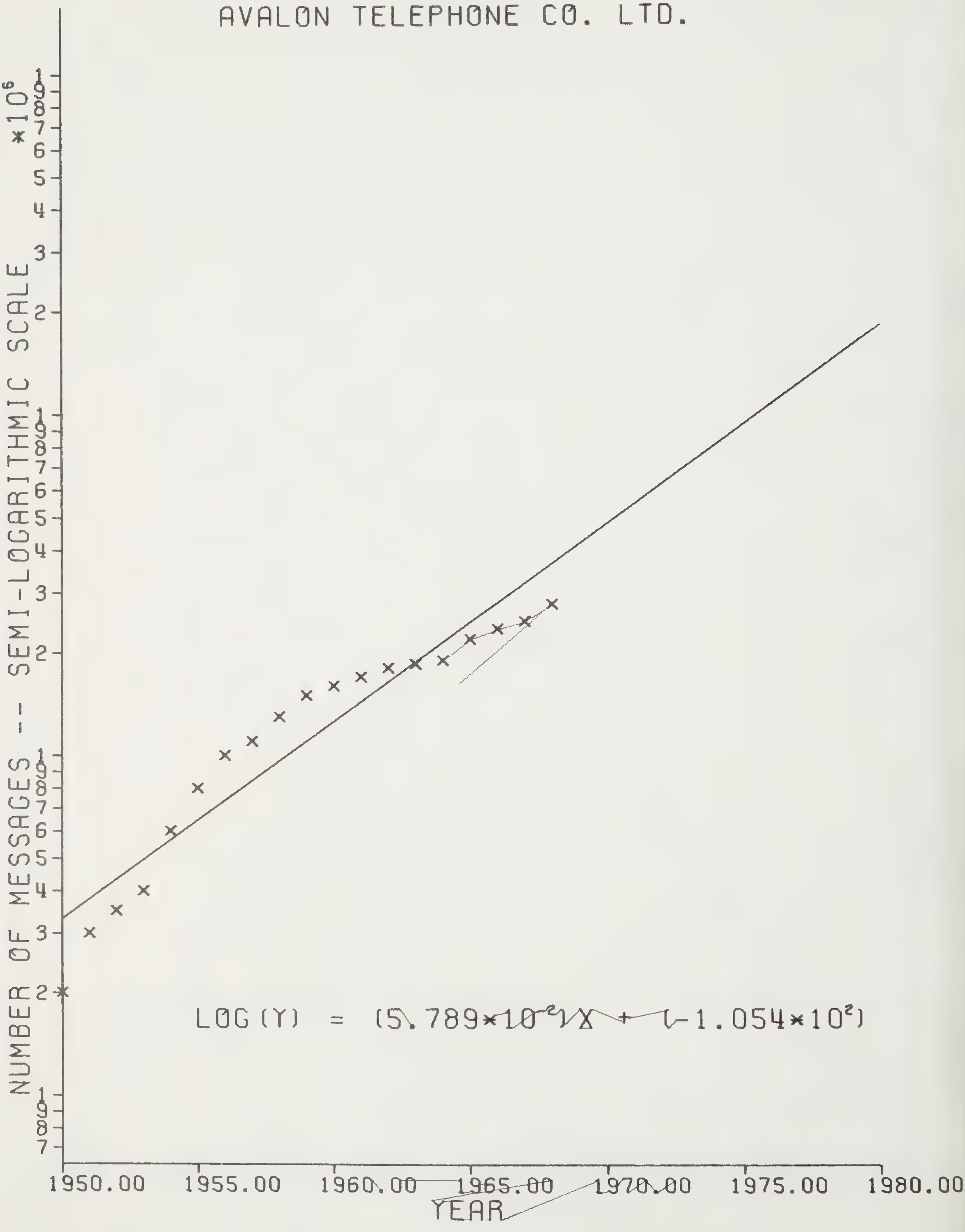
Nevertheless these figures seemed of descriptive value and are therefore appended. The vertical scale is logarithmic and the coefficients of X in the equations may be converted to annual growth rates by division by 0.338.

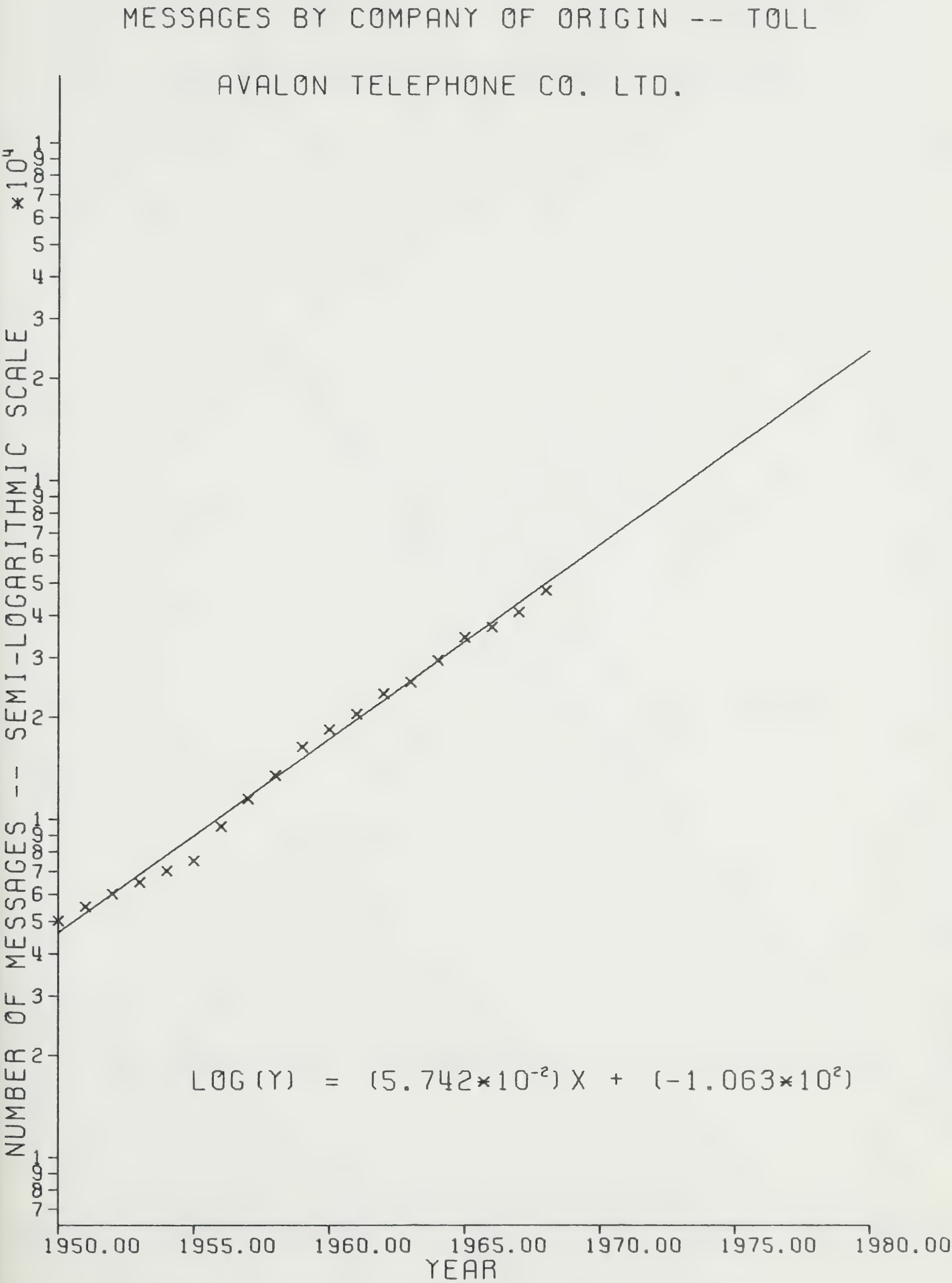

MESSAGES BY COMPANY OF ORIGIN -- LOCAL
TOTALS
NUMBER OF MESSAGES -- SEMI-LOGARITHMIC SCALE *10^9
3
2
1
9
8
7
6
5
LOG(Y) = (2.670*10^-2) X + (-4.242*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

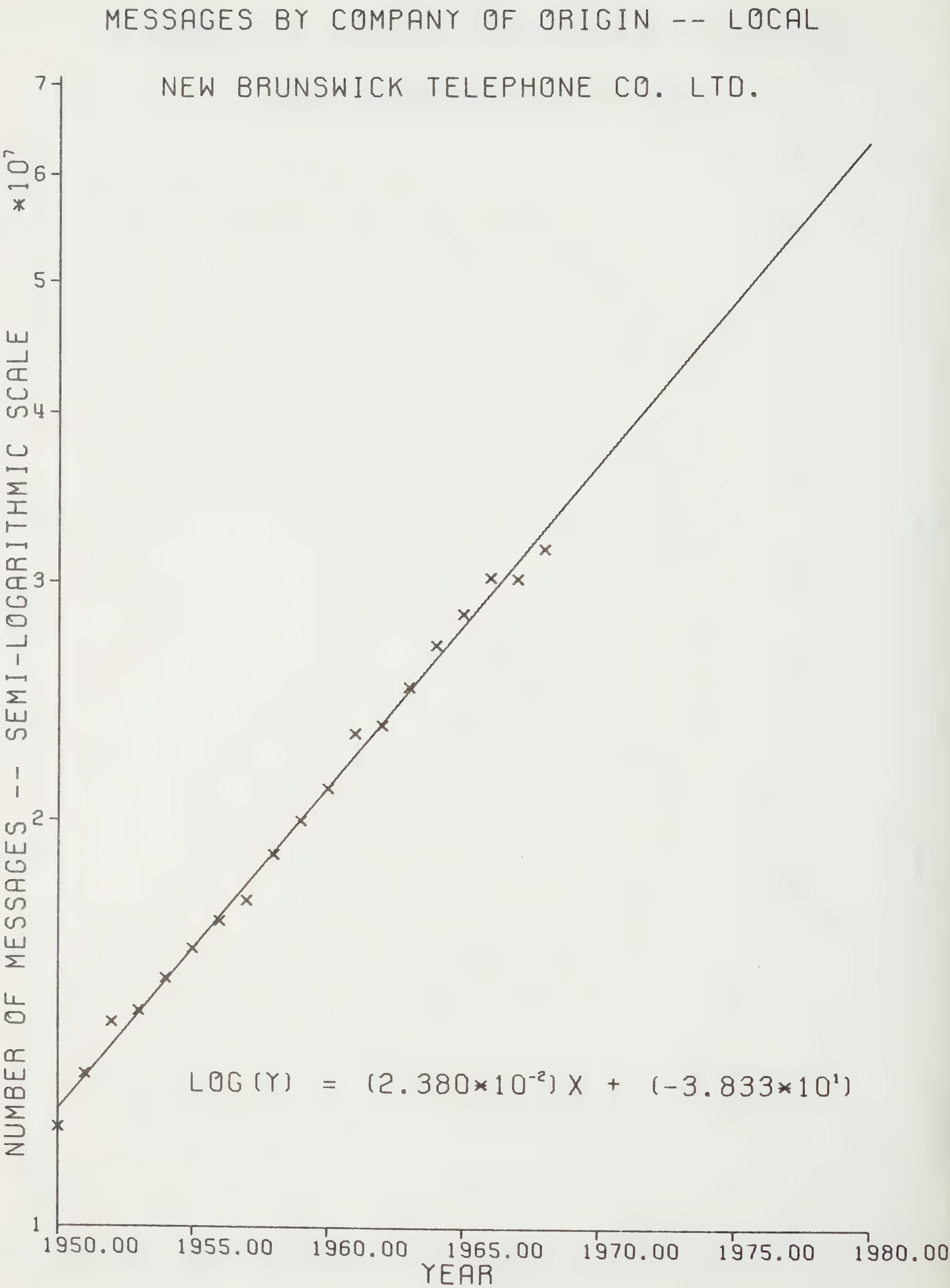

MESSAGES BY COMPANY OF ORIGIN -- TOLL
TOTALS
NUMBER OF MESSAGES -- SEMI-LOGARITHMIC SCALE *10^8
8
7
6
5
4
3
2
LOG(Y) = (2.769×10^-2) X + (-4.593×10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

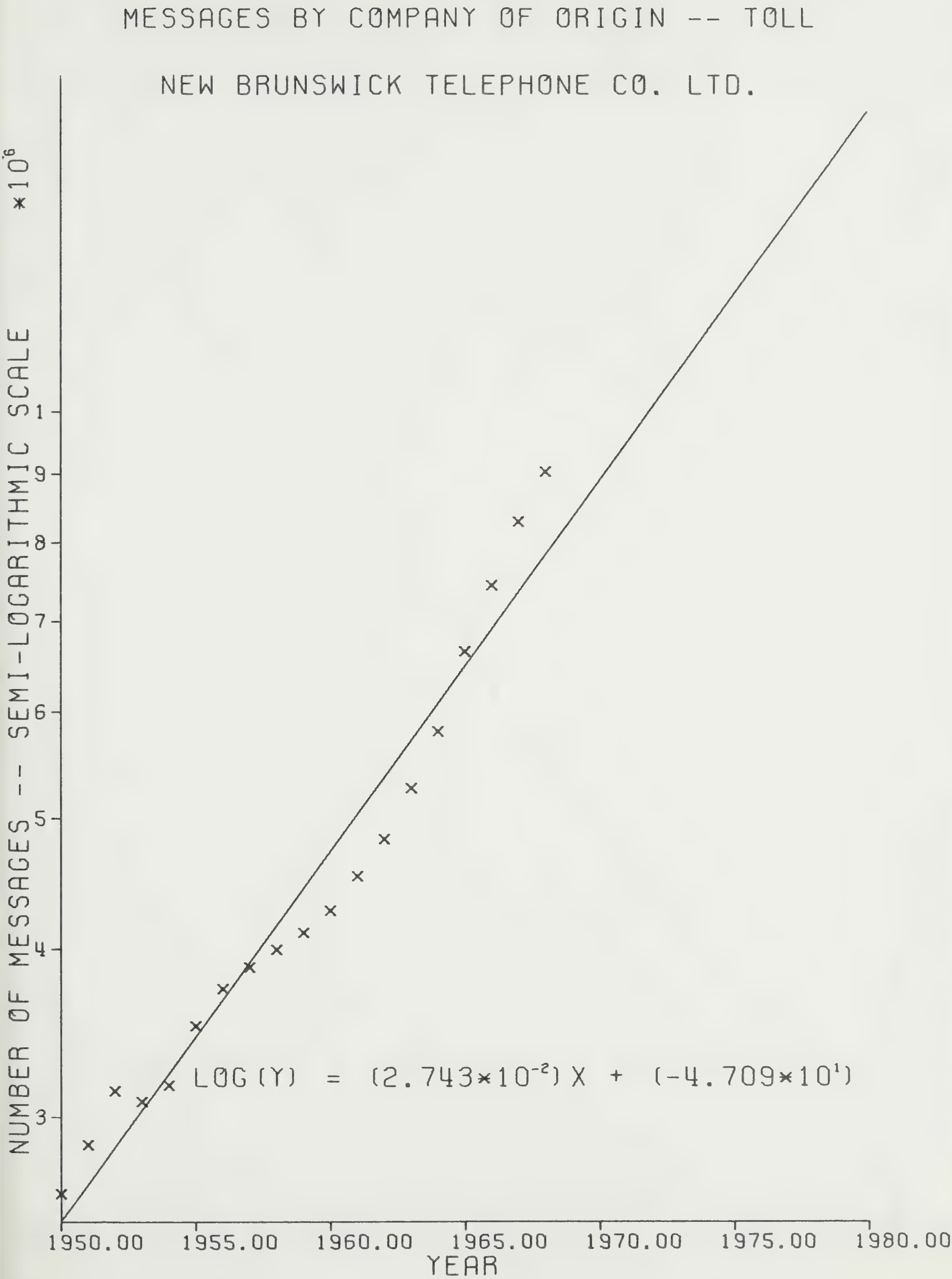
MESSAGES BY COMPANY OF ORIGIN -- LOCAL

AVALON TELEPHONE CO. LTD.

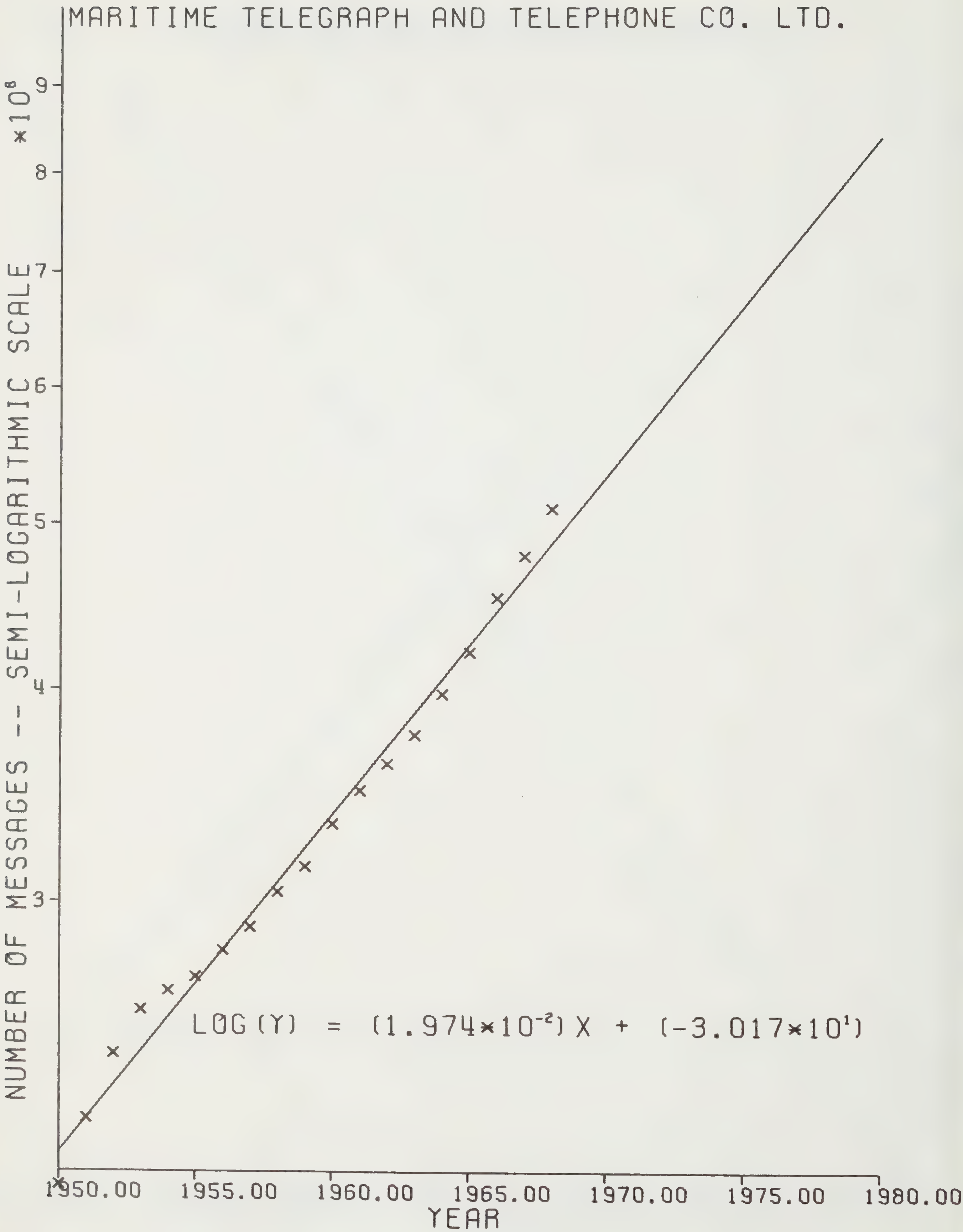


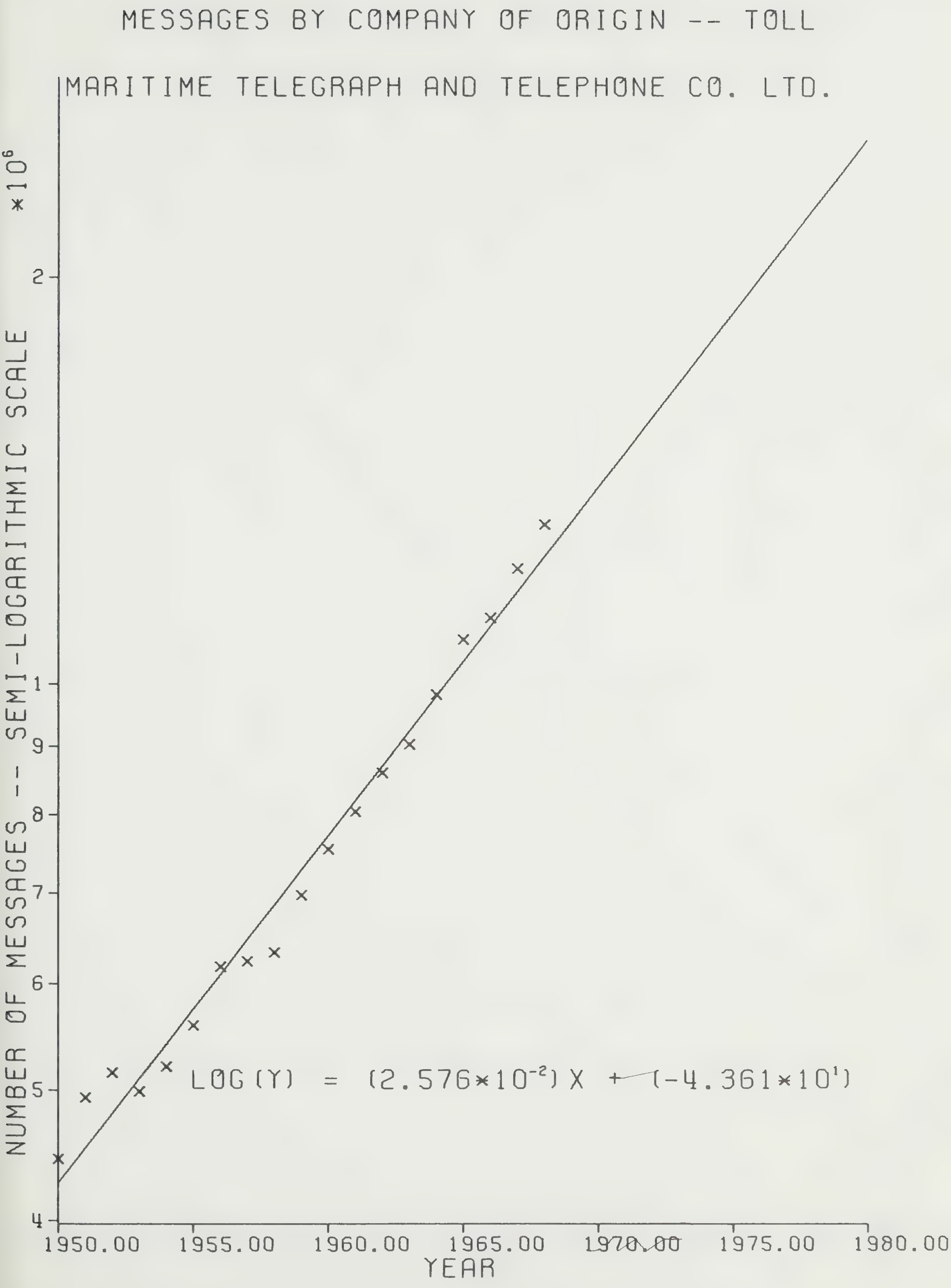

MESSAGES BY COMPANY OF ORIGIN -- TOLL
AVALON TELEPHONE CO. LTD.
NUMBER OF MESSAGES -- SEMI-LOGARITHMIC SCALE *10^4
LOG(Y) = (5.742*10^-2) X + (-1.063*10^2)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

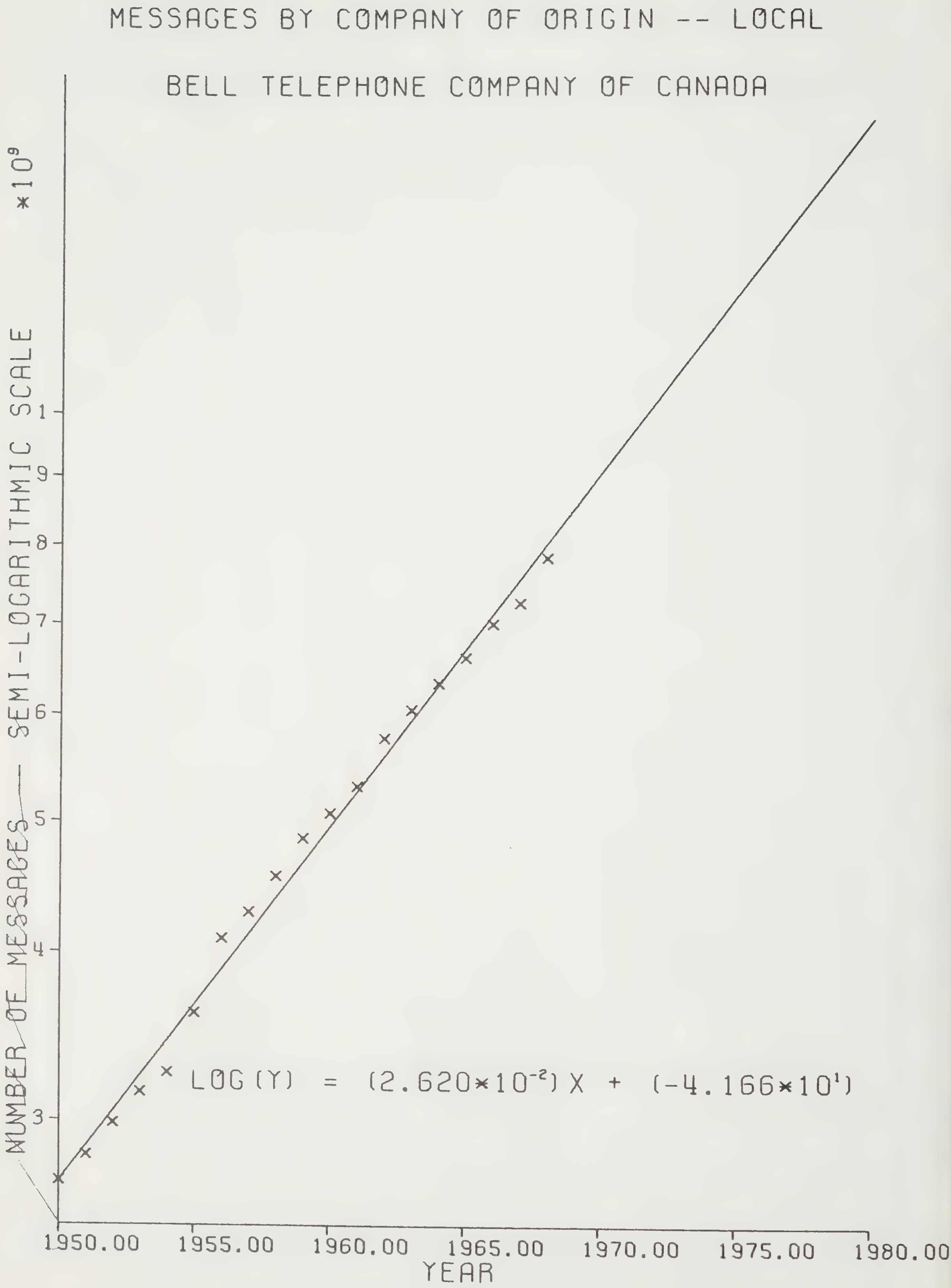

MESSAGES BY COMPANY OF ORIGIN -- LOCAL
NEW BRUNSWICK TELEPHONE CO. LTD.
NUMBER OF MESSAGES -- SEMI-LOGARITHMIC SCALE *10^7
1
2
3
4
5
6
7
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR
LOG(Y) = (2.380*10^-2) X + (-3.833*10^1)

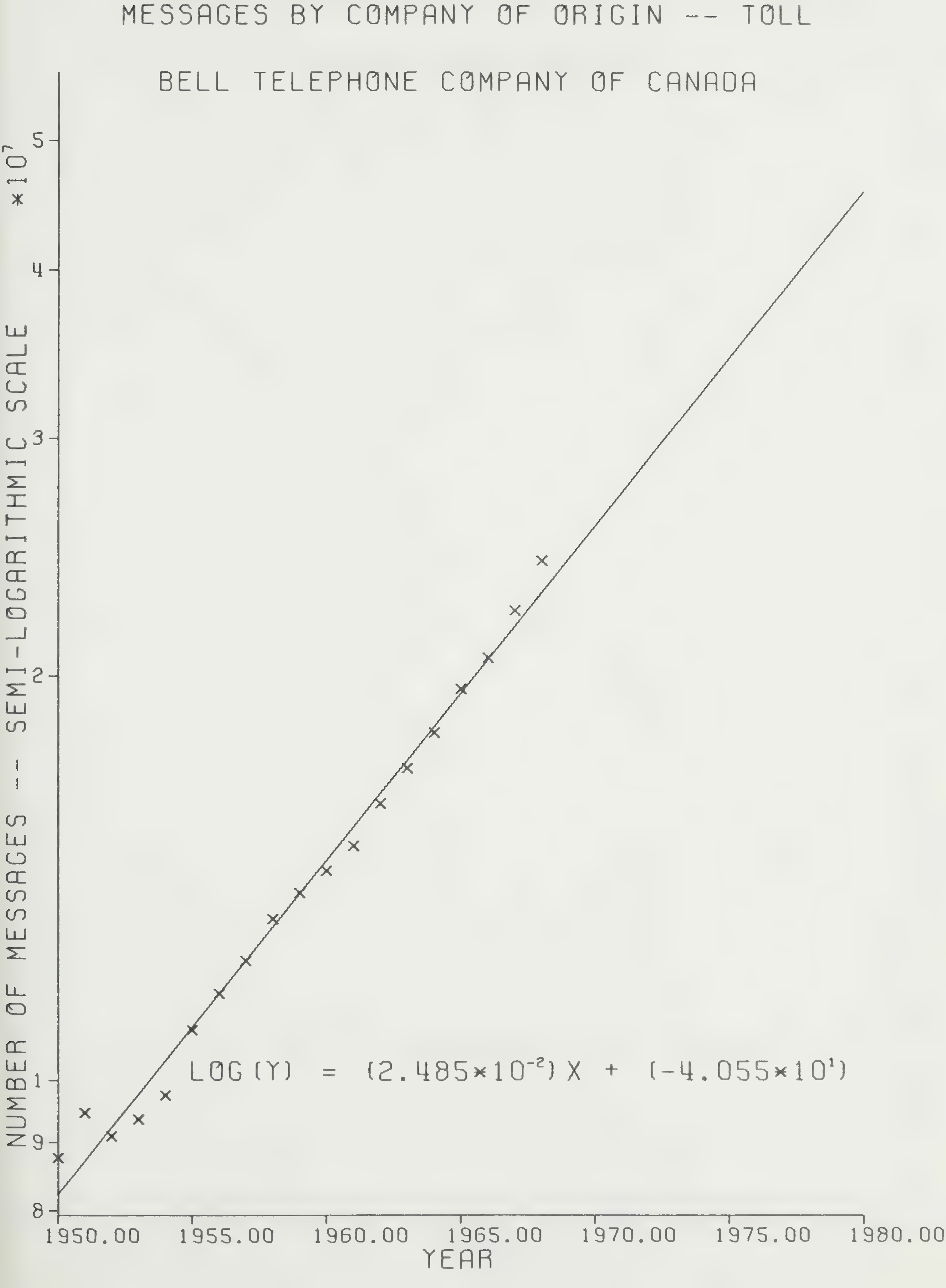

MESSAGES BY COMPANY OF ORIGIN -- TOLL
NEW BRUNSWICK TELEPHONE CO. LTD.
NUMBER OF MESSAGES -- SEMI-LOGARITHMIC SCALE *10^6
1
9
8
7
6
5
4
3
LOG(Y) = (2.743*10^-2) X + (-4.709*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

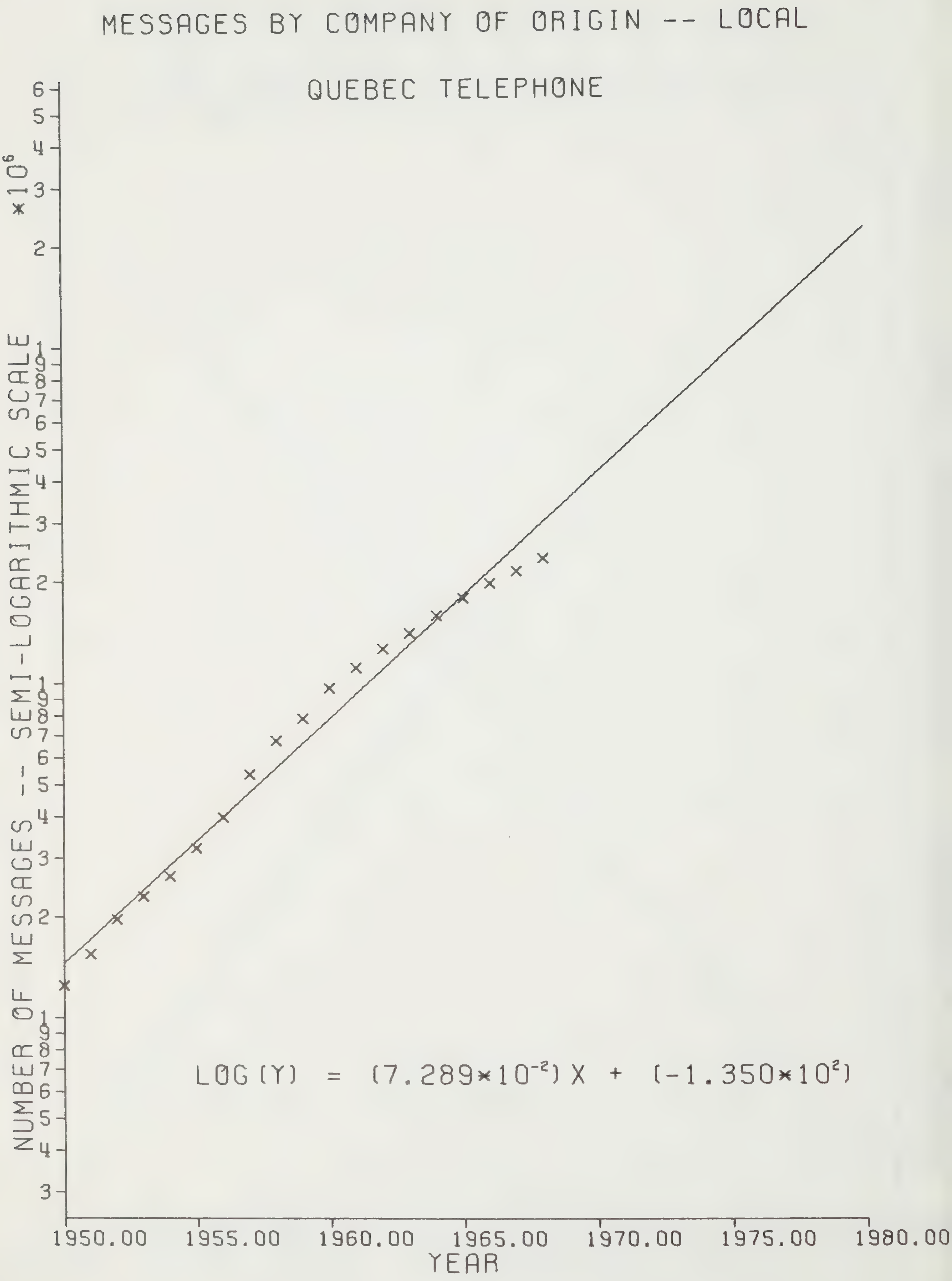
MESSAGES BY COMPANY OF ORIGIN -- LOCAL

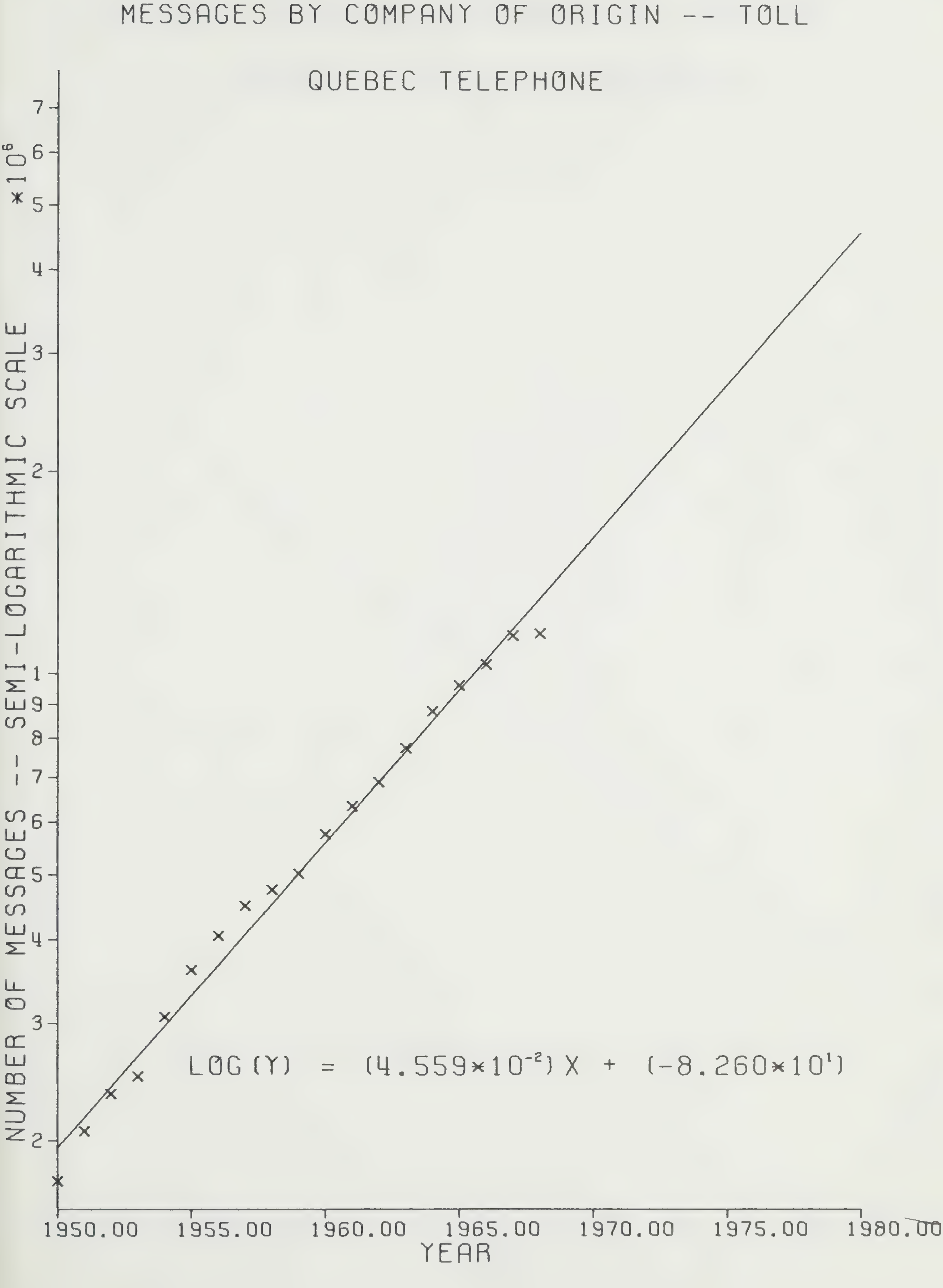



MESSAGES BY COMPANY OF ORIGIN -- TOLL
MARITIME TELEGRAPH AND TELEPHONE CO. LTD.
NUMBER OF MESSAGES -- SEMI-LOGARITHMIC SCALE *10⁶
2
1
9
8
7
6
5
4
LOG(Y) = (2.576*10⁻²) X + (-4.361*10¹)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

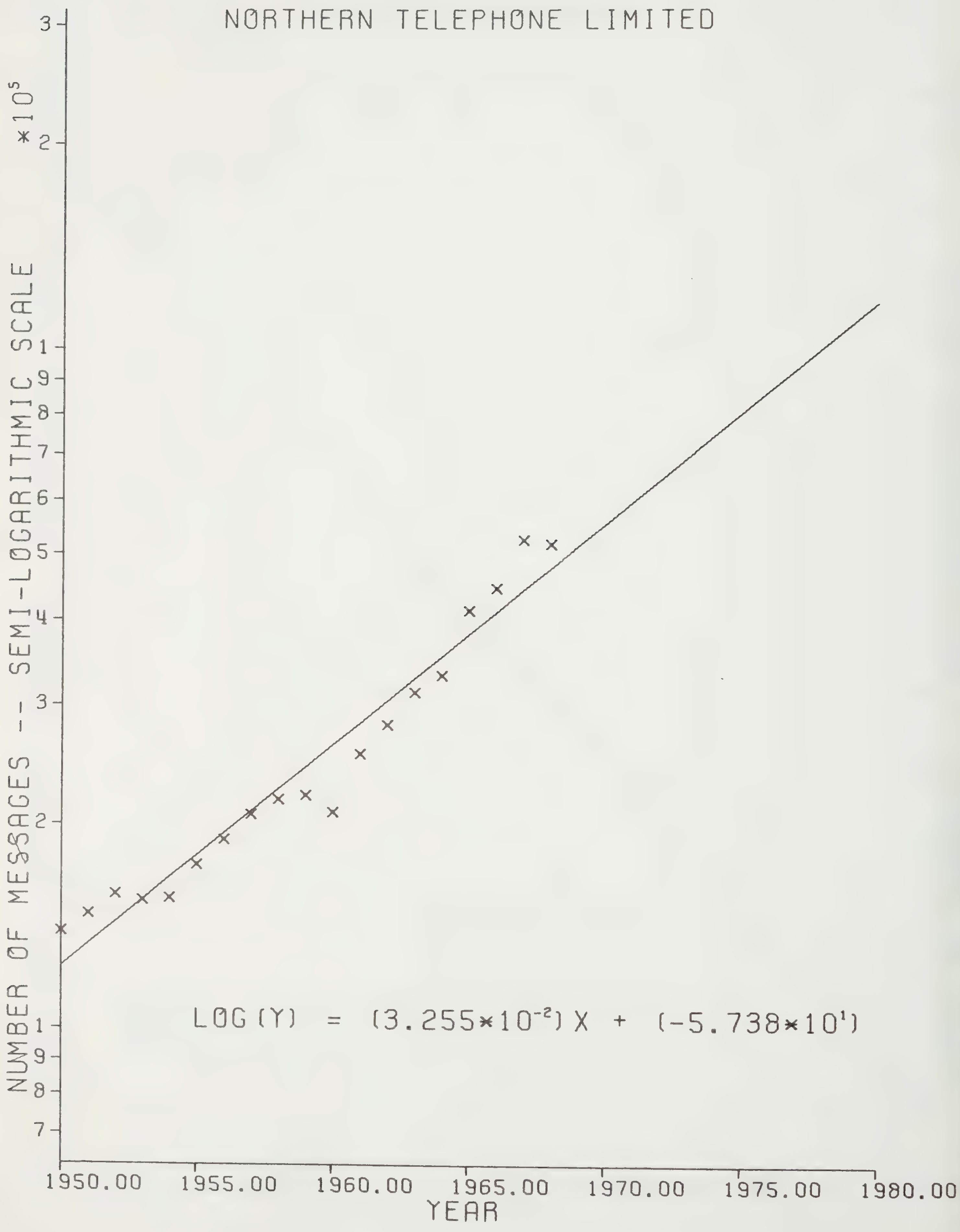

MESSAGES BY COMPANY OF ORIGIN -- LOCAL
BELL TELEPHONE COMPANY OF CANADA
NUMBER OF MESSAGES — SEMI-LOGARITHMIC SCALE *10⁹
1
9
8
7
6
5
4
3
LOG(Y) = (2.620*10⁻²) X + (-4.166*10¹)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

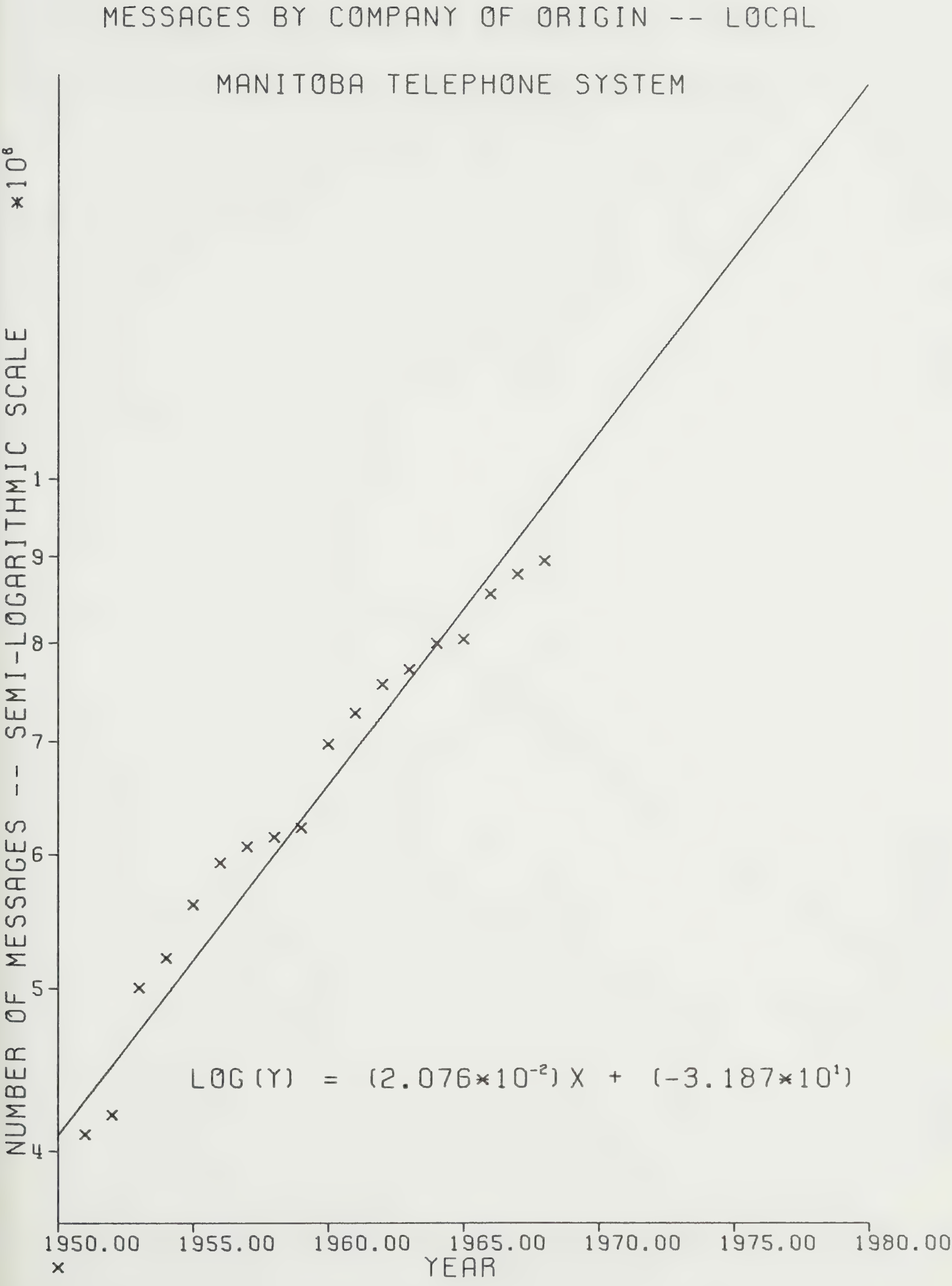

MESSAGES BY COMPANY OF ORIGIN -- TOLL
BELL TELEPHONE COMPANY OF CANADA
NUMBER OF MESSAGES -- SEMI-LOGARITHMIC SCALE *10^7
5
4
3
2
1
9
8
LOG(Y) = (2.485*10^-2) X + (-4.055*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

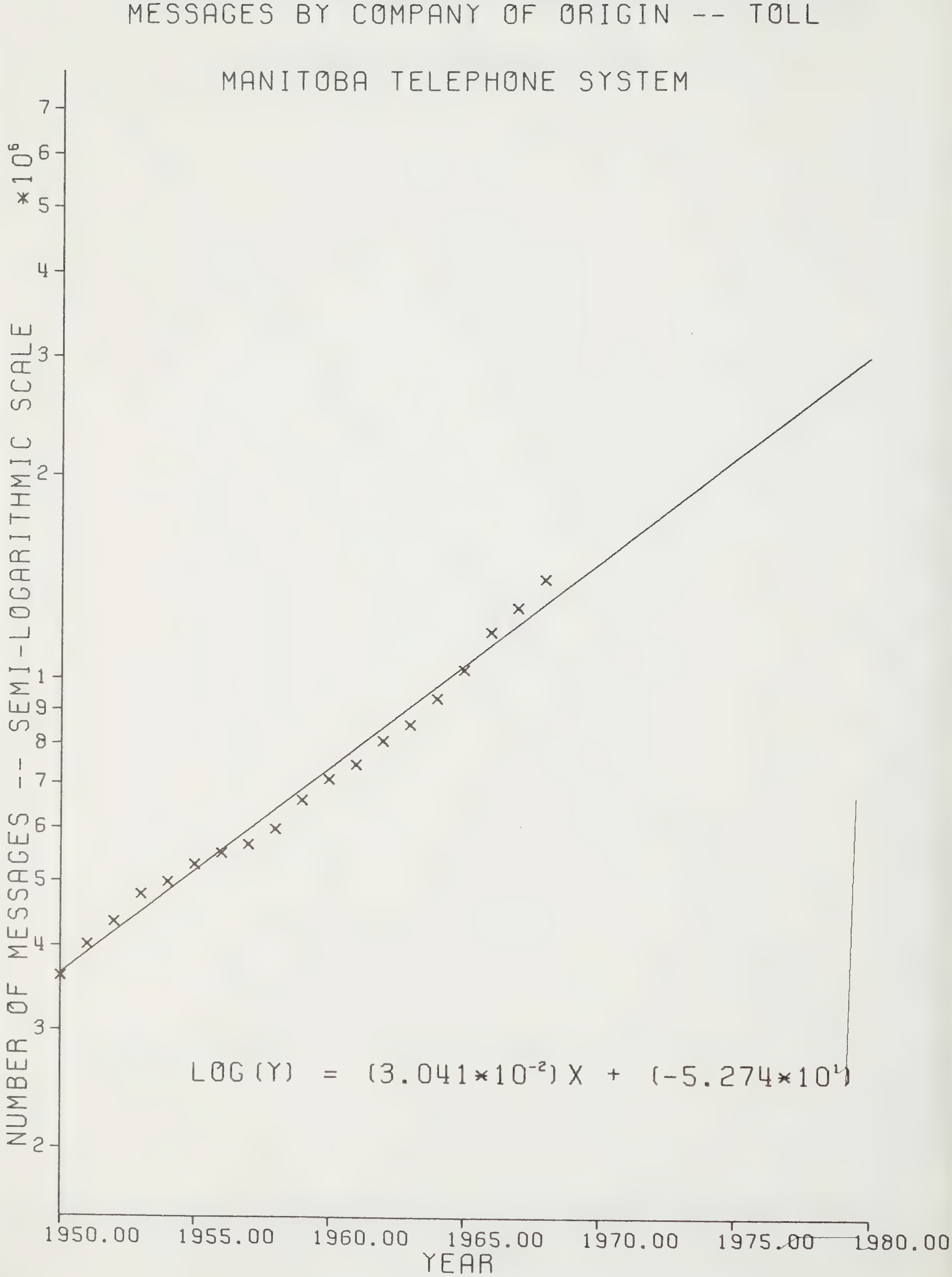

MESSAGES BY COMPANY OF ORIGIN -- LOCAL
QUEBEC TELEPHONE
NUMBER OF MESSAGES -- SEMI-LOGARITHMIC SCALE
*10^6
LOG(Y) = (7.289*10^-2) X + (-1.350*10^2)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

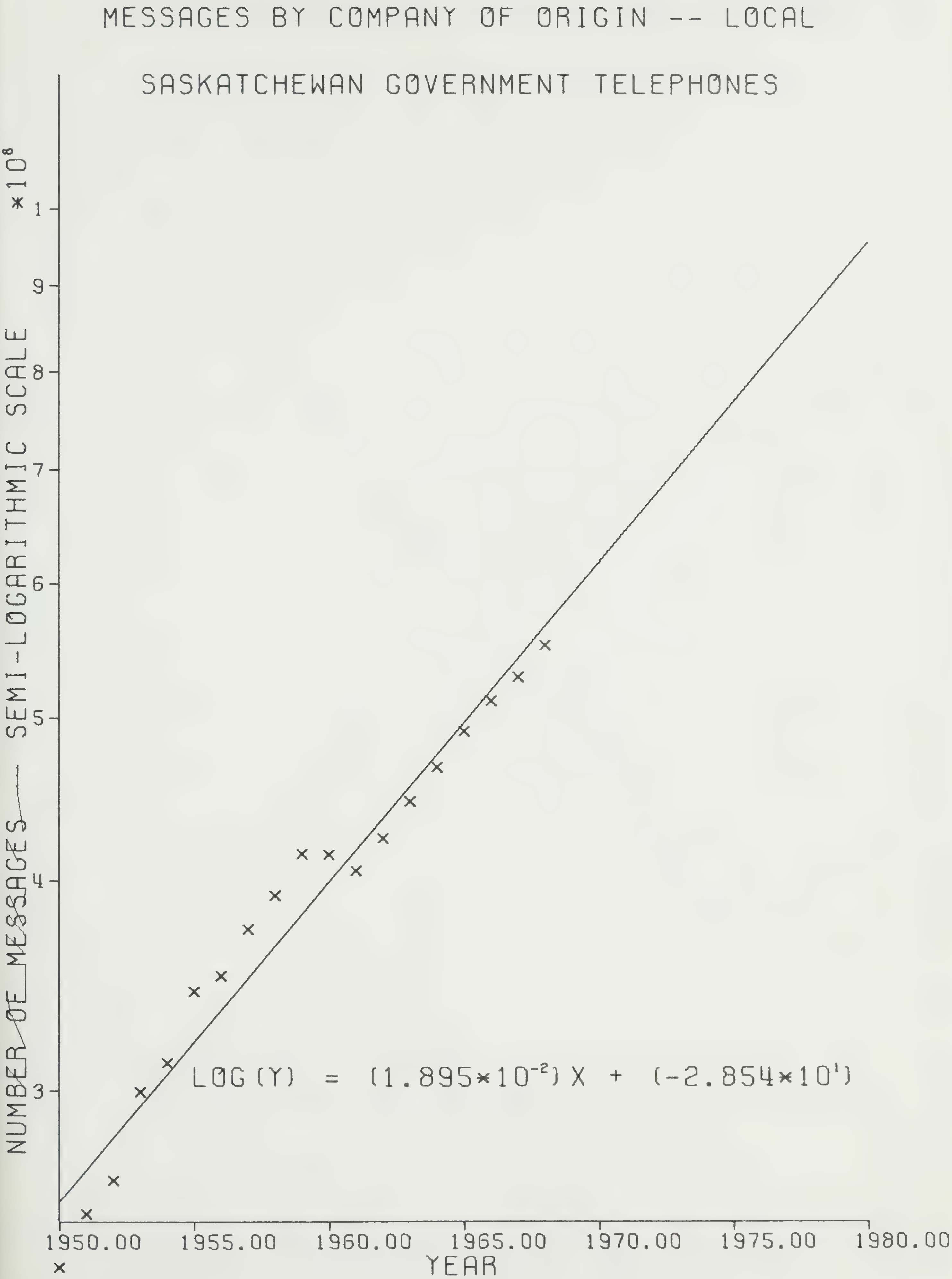

MESSAGES BY COMPANY OF ORIGIN -- TOLL
QUEBEC TELEPHONE
NUMBER OF MESSAGES -- SEMI-LOGARITHMIC SCALE *10^6
7
6
5
4
3
2
1
9
8
7
6
5
4
3
2
LOG(Y) = (4.559×10^-2) X + (-8.260×10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

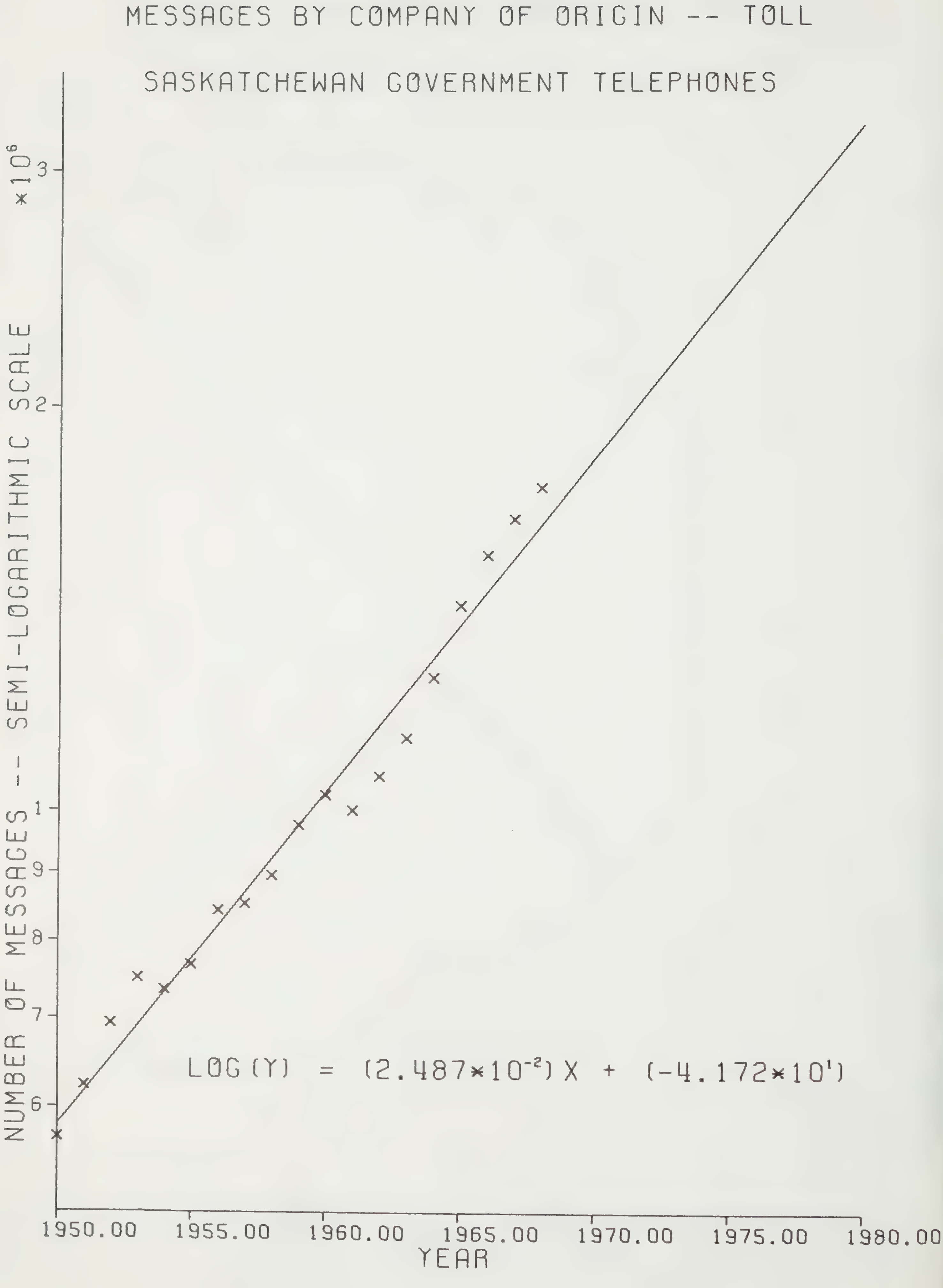
MESSAGES BY COMPANY OF ORIGIN -- TOLL

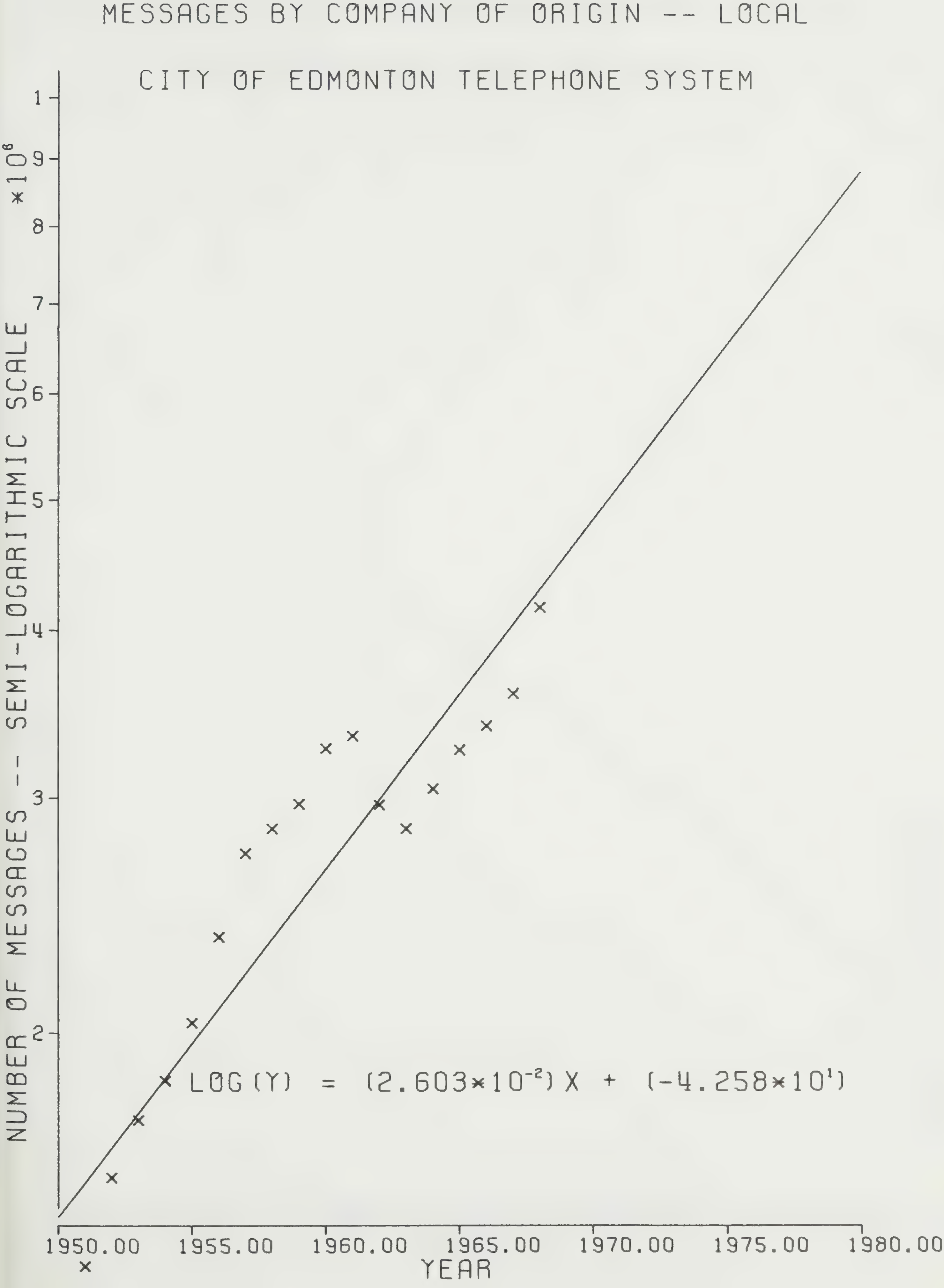


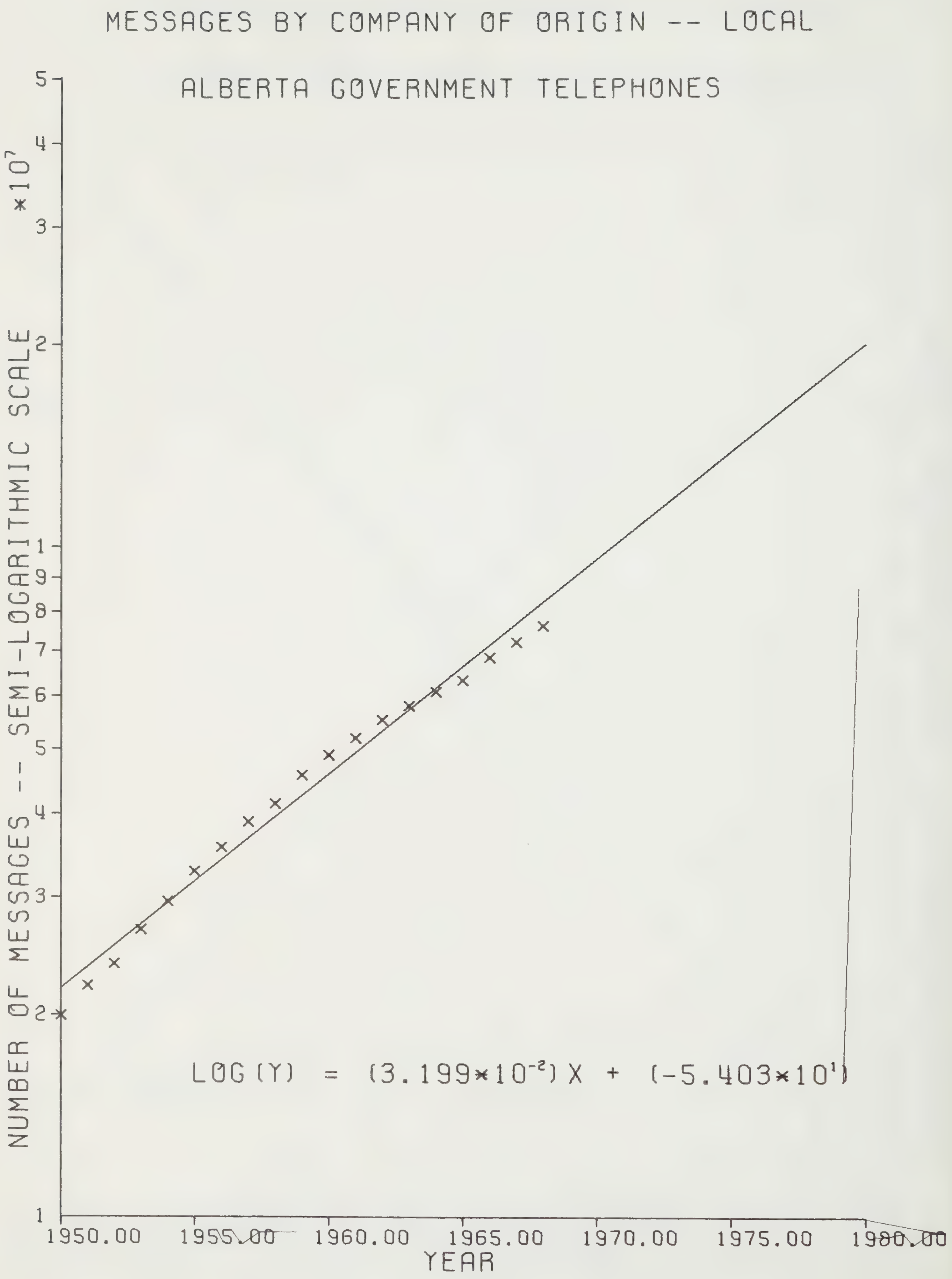

MESSAGES BY COMPANY OF ORIGIN -- LOCAL
MANITOBA TELEPHONE SYSTEM
NUMBER OF MESSAGES -- SEMI-LOGARITHMIC SCALE *10^8
1
9
8
7
6
5
4
LOG(Y) = (2.076*10^-2) X + (-3.187*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
X
YEAR

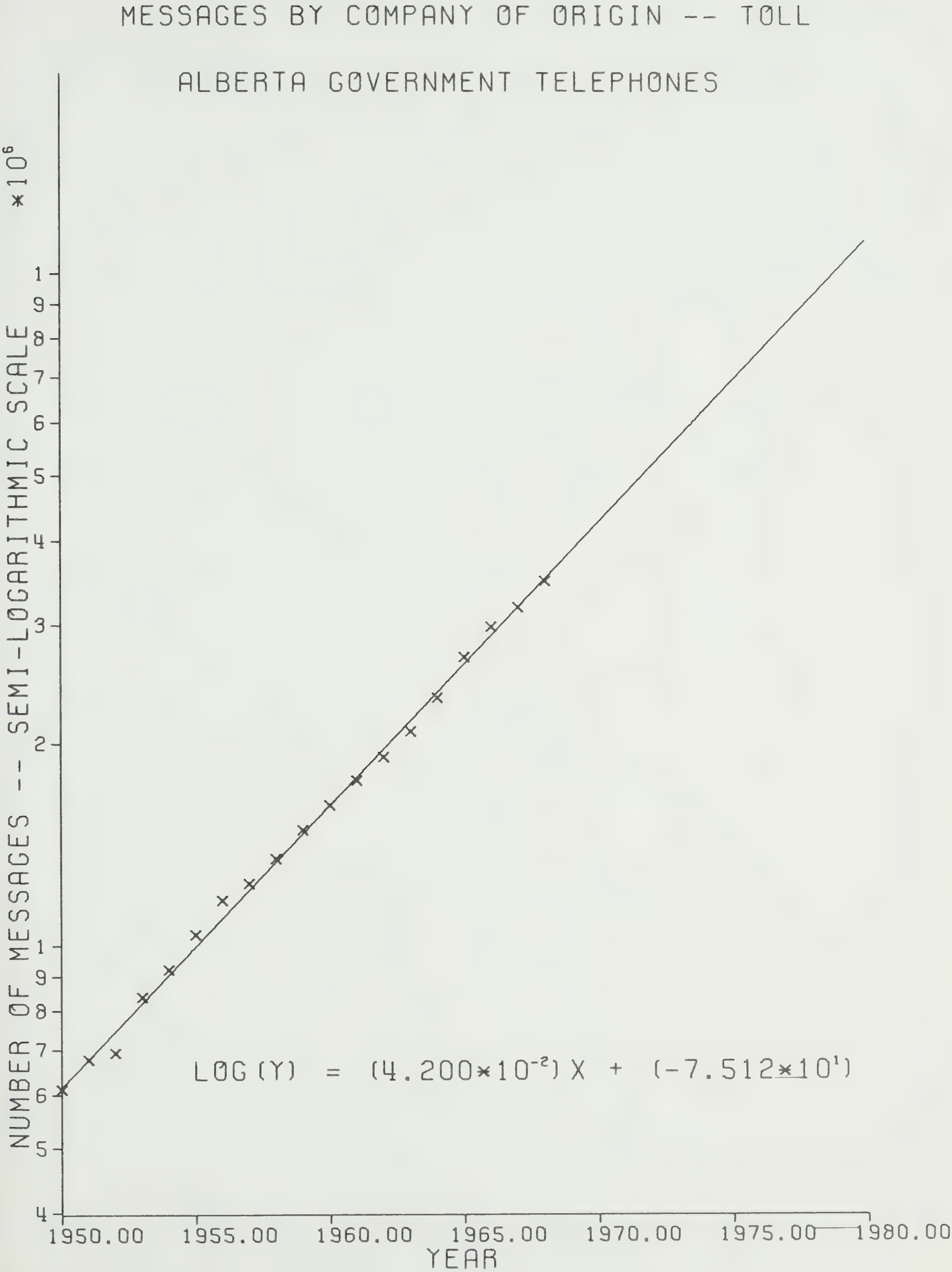

MESSAGES BY COMPANY OF ORIGIN -- TOLL
MANITOBA TELEPHONE SYSTEM
NUMBER OF MESSAGES -- SEMI-LOGARITHMIC SCALE *10^6
7
6
5
4
3
2
1
9
8
7
6
5
4
3
2
LOG(Y) = (3.041*10^-2) X + (-5.274*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

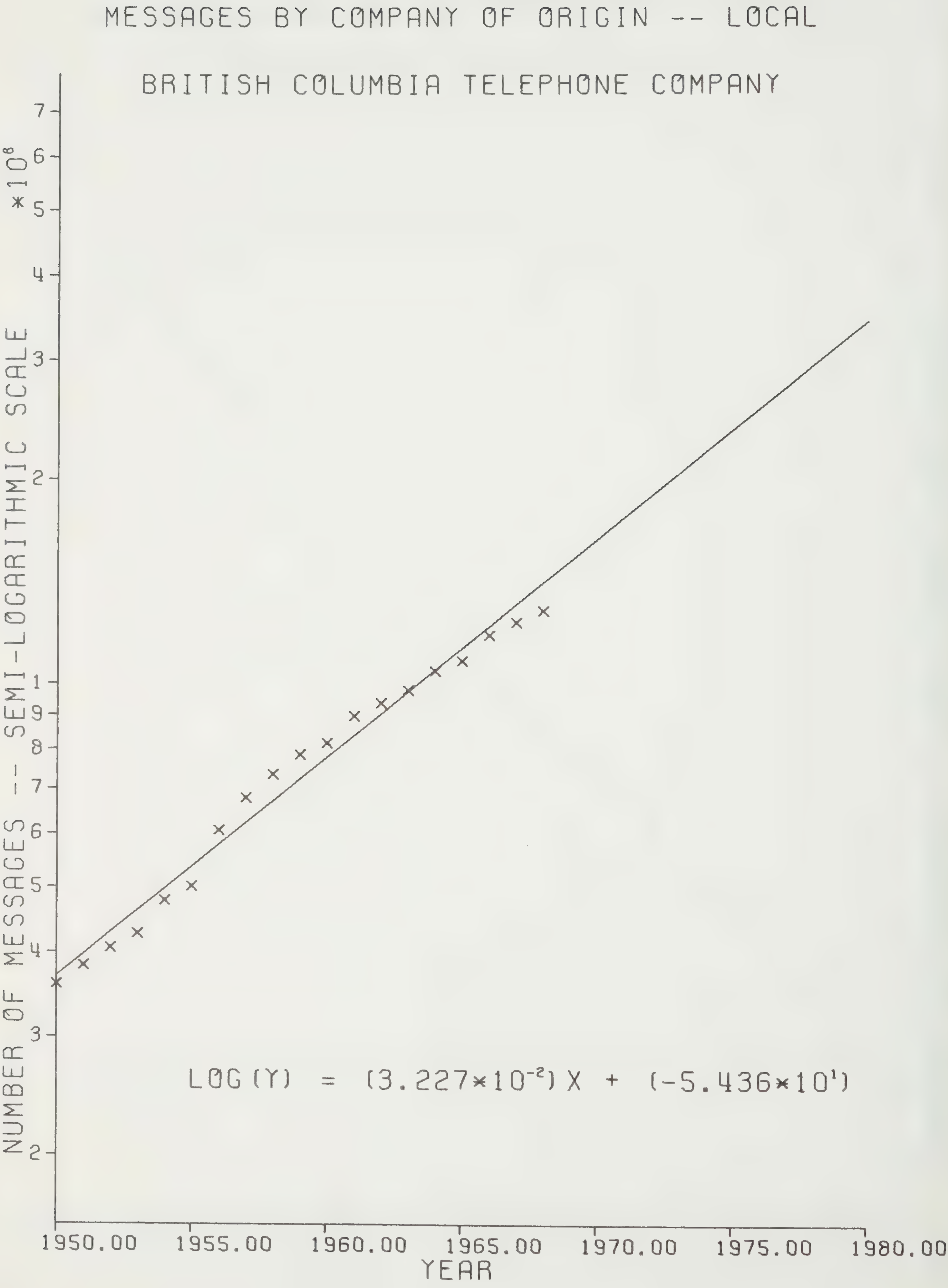

MESSAGES BY COMPANY OF ORIGIN -- LOCAL
SASKATCHEWAN GOVERNMENT TELEPHONES
NUMBER OF MESSAGES — SEMI-LOGARITHMIC SCALE
*10^8
1
9
8
7
6
5
4
3
LOG(Y) = (1.895*10^-2) X + (-2.854*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

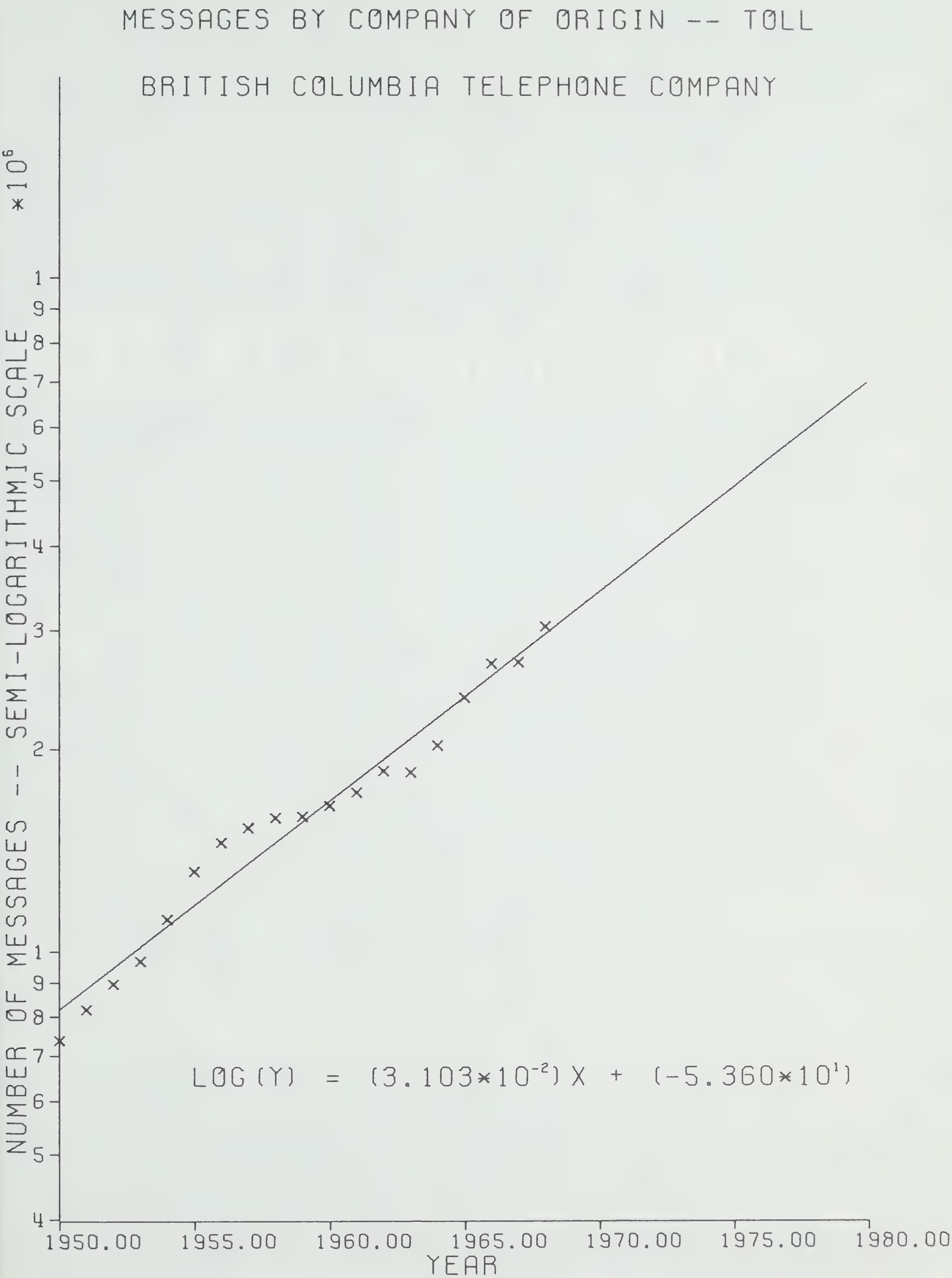

MESSAGES BY COMPANY OF ORIGIN -- TOLL
SASKATCHEWAN GOVERNMENT TELEPHONES
NUMBER OF MESSAGES -- SEMI-LOGARITHMIC SCALE *10^6
3
2
1
9
8
7
6
LOG(Y) = (2.487*10^-2) X + (-4.172*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR


MESSAGES BY COMPANY OF ORIGIN -- LOCAL
CITY OF EDMONTON TELEPHONE SYSTEM
NUMBER OF MESSAGES -- SEMI-LOGARITHMIC SCALE *10^8
LOG(Y) = (2.603*10^-2) X + (-4.258*10^1)
YEAR
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
1
9
8
7
6
5
4
3
2

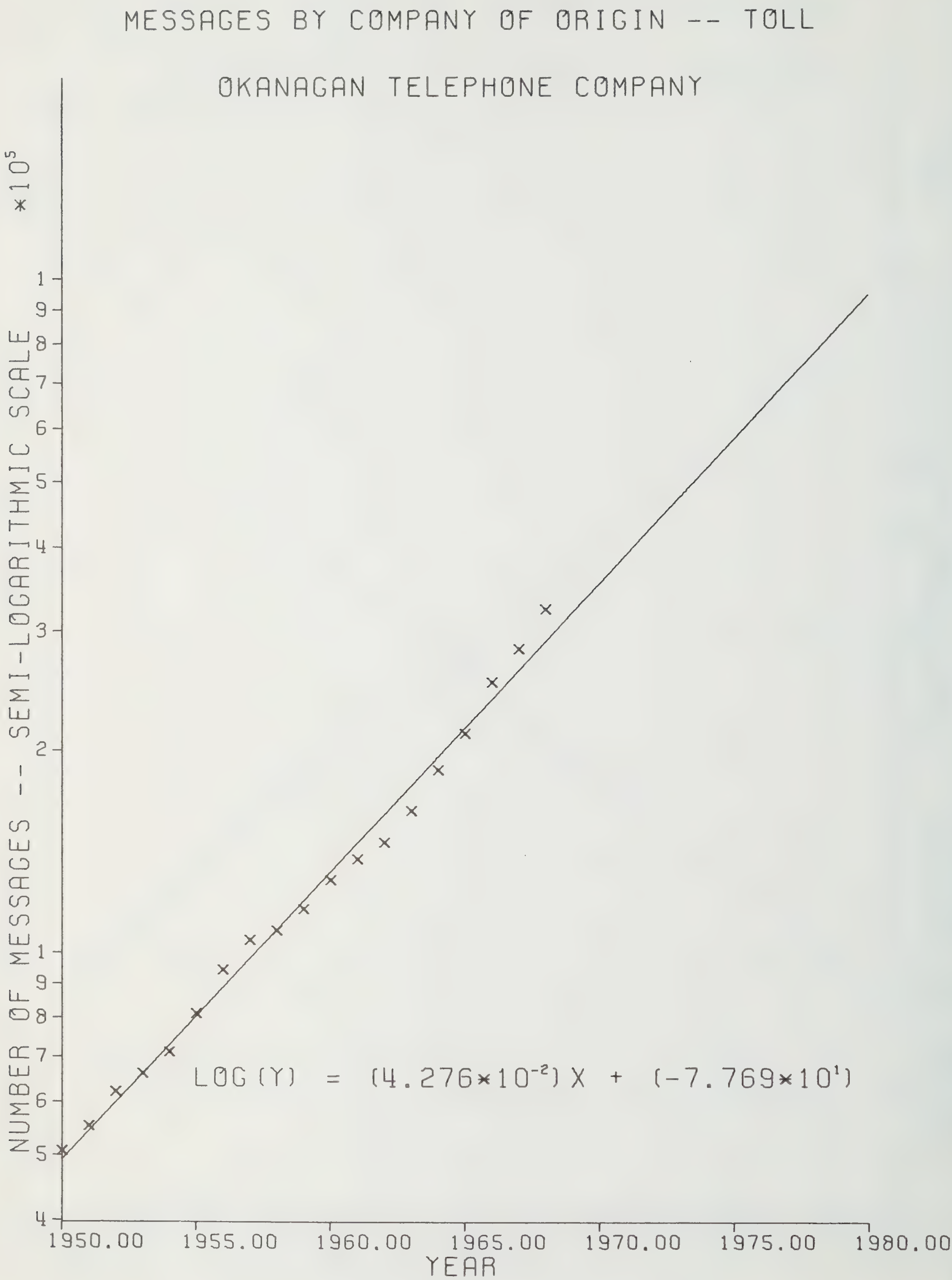

MESSAGES BY COMPANY OF ORIGIN -- LOCAL
ALBERTA GOVERNMENT TELEPHONES
NUMBER OF MESSAGES -- SEMI-LOGARITHMIC SCALE *10^7
5
4
3
2
1
9
8
7
6
5
4
3
2
1
LOG(Y) = (3.199*10^-2) X + (-5.403*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR


MESSAGES BY COMPANY OF ORIGIN -- TOLL
ALBERTA GOVERNMENT TELEPHONES
NUMBER OF MESSAGES -- SEMI-LOGARITHMIC SCALE *10^6
1
9
8
7
6
5
4
3
2
1
9
8
7
6
5
4
LOG(Y) = (4.200*10^-2) X + (-7.512*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR


MESSAGES BY COMPANY OF ORIGIN -- LOCAL
BRITISH COLUMBIA TELEPHONE COMPANY
NUMBER OF MESSAGES -- SEMI-LOGARITHMIC SCALE *10^8
7
6
5
4
3
2
1
9
8
7
6
5
4
3
2
LOG(Y) = (3.227*10^-2) X + (-5.436*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR



MESSAGES BY COMPANY OF ORIGIN -- TOLL
BRITISH COLUMBIA TELEPHONE COMPANY
NUMBER OF MESSAGES -- SEMI-LOGARITHMIC SCALE *10^6
1
9
8
7
6
5
4
3
2
1
9
8
7
6
5
4
LOG(Y) = (3.103*10^-2) X + (-5.360*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR


MESSAGES BY COMPANY OF ORIGIN -- TOLL
OKANAGAN TELEPHONE COMPANY
NUMBER OF MESSAGES -- SEMI-LOGARITHMIC SCALE *10^5
1
9
8
7
6
5
4
3
2
1
9
8
7
6
5
4
LOG(Y) = (4.276*10^-2) X + (-7.769*10^1)
1950.00
1955.00
1960.00
1965.00
1970.00
1975.00
1980.00
YEAR

TELECOMMISSION

Study 2(c)

Spectrum Management: An Integrated Model of Management Alternatives and their Economic Implications

The Department of Communications

SPECTRUM MANAGEMENT:

AN INTEGRATED MODEL OF MANAGEMENT ALTERNATIVES AND THEIR ECONOMIC IMPLICATIONS

for

DEPARTMENT OF COMMUNICATIONS
OTTAWA

July 1970

Authors: Dr. A.R. Elliott
Dr. J.P. Liefeld
Mr. R.J. Spence

CENTRE FOR APPLIED RESEARCH AND ENGINEERING DESIGN
INCORPORATED

McMASTER UNIVERSITY
HAMILTON, ONTARIO

Available by mail from Information Canada, Ottawa,
and at the following Information Canada bookshops:

HALIFAX
1735 Barrington Street

MONTREAL
1182 St. Catherine Street West

OTTAWA
171 Slater Street

TORONTO
221 Yonge Street

WINNIPEG
393 Portage Avenue

VANCOUVER
657 Granville Street

or through your bookseller

Price $1.50 Catalogue No. Co41-½C

Price subject to change without notice

Information Canada
Ottawa, 1971

ACKNOWLEDGEMENTS

The authors wish to express their appreciation for the advice, counsel and information received from the staff of the Department of Communications and the many spectrum users who gave generously of their time and the benefits of their experience. This cooperation and the high degree of openness in these interactions greatly simplified the task facing the study group.

PREFACE

The purposes of this study are set out in the following terms of reference:

(a) Formulate a philosophy for the incorporation of economic value into the management of the radio spectrum, with particular attention to economic incentives to encourage maximum information flow in spectrum management.

(b) Determine what economic guidelines based on sound technical considerations are available to relieve congestion either existing or anticipated on the radio spectrum.

(c) Review economic approaches to the apportionment of scarce radio bands among competing users.

(d) Consider how technological advances may be applied to increasing the efficient use of the spectrum with particular emphasis on economic costs and benefits.

(e) Explore economic guidelines to assist spectrum managers in apportioning the costs of spectrum management including those of frequency reassignment and interference correction.

(f) Study spectrum management techniques and economic incentives to further sound development of more isolated points of Canada with particular attention to the North.

(g) Identify any cases where the introduction of new radio services would be facilitated by particular management policies or devices.

As is evident, in these terms of reference, this study is not directed at choosing objectives for spectrum management. Accordingly, we are not concerned with deciding if the encouragement of spectrum utilization, the encouragement of new radio services, the use of either economic, social or political guidelines or some mixture of these, should be the objectives of spectrum mangement. Rather we are concerned with advising how any of these objectives might be achieved. If the spectrum managers want to encourage utilization in isolated areas, we suggest ways in which this might be achieved. Similarly for any other objective desired, we suggest how it might be achieved.

The report is divided into 5 chapters. Chapter 1 discusses: (1) the nature of the allocation problem; and, (2) the possible conditions of supply of and demand for spectrum which may exist at any point in time and in any region or locality. Chapter 2 discusses band reallocation solutions to problems of an excess of demand over supply of spectrum. Chapter 3 discusses technical solutions to excess demand. Chapter 4 discusses the exclusion of some users as a solution to excess demand. Finally, Chapter 5 presents a summary and conclusion.

TABLE OF CONTENTS

Page

Page

Page

LIST OF ILLUSTRATIONS

CHAPTER 1

INTRODUCTION

1.1 THE PROBLEM: ALLOCATION OF A NATIONAL RESOURCE

1.1.1 Rationale

The radio spectrum is a national resource. It belongs to all the people of Canada, not to any particular individual or group of individuals. The Government of Canada, the administrative service which expresses the will of the Canadian people, is charged with allocating this resource (among others).

If allocation were not controlled, and any individual or several individuals utilized this resource without respect to the rights of each other or other people in the society, chaos would result (a state of entropy)[1]. It is apparent, therefore, that the underlying objective of resource allocation must be to minimize and/or exclude entropy and thus simultaneously maximize the benefits received from the resource by the people of Canada.

These benefits may include economic benefits and/or social benefits. The particular relative weight assigned to economic and/or social benefits should reflect the will of the Canadian people. The government, and not these authors, must decide the relative importance of these types of benefits.

We can categorically state, however, that the minimizing or exclusion of entropy in the allocation of this resource is the basic management problem. Any entropy which occurs is a cost (economic and/or social) to society. By minimizing or excluding this cost we simultaneously maximize the benefits received from the resource.

---

1. By entropy we mean: at any point in time the state of the world and the phenomenon within it may or may not be suitable for man's purposes. When the state is not suitable the energy and will of man must be applied to create order for his purposes. Any events which interfere with man's purposes can be called entropy effects and are costs or losses to the achievement of those purposes.

Historically the allocation of the radio spectrum has been approached by dividing it up into "Bands" and specifying the type of use allowed within a band. These allocation decisions are critical, for if they do not adequately take account of the nature and quantity of future demand for spectrum usage, or future technological progress, allocational problems will occur. It is reasonable to conclude that:

(1) if band allocation properly assesses future conditions no problems will occur;

(2) the adequacy of any given band allocation is determined by how well it predicts future conditions;

(3) band allocation is an exercise in <u>planning</u>;

(4) since the future is not entirely predictable no allocation of bands can be viewed as final; and,

(5) if conditions begin to depart from expectations it is necessary to change band allocations sufficiently ahead of demand or technological change to avoid incurring economic or social costs.

The remainder of this section considers: (1) What are the principles of planning; (2) what units (national-regional-local) of planning are available; and, (3) what constraints impinge upon the planning of band allocation.

1.1.2 Principles of Planning

Allocation of bands is an exercise in planning. Therfore, it is necessary to understand what plans are and what basic principles apply to this activity. The following quotations provide the basis for understanding the nature of and principles of planning.

> "Plans are made to operate in the future. Therefore a key part of planning is the establishment of clear planning premises. --- premises guide planning. They spell out the 'stage' of the expected future events which is believed will exist when plans operate. They are the expected environment of plans."[1]

> "When you plan you choose certain course of action and rule out others. Ruling out other actions ties you down and takes away flexibility. This can become a disadvantage if the future turns out differently from what you expected. Your current plans may no longer be suitable and, if they aren't, you'd better make up new ones to adapt to current conditions. Try to make up plans that you can change at reasonable cost if you have to. It's a bad plan that admits no change."[2]

The above provides the basic principles required to approach the task of allocating bands.

1.1.2.1. Knowledge of Future Events: Premises

A state of knowledge or estimate about future conditions affecting the allocation of radio spectrum must be developed. Since we cannot predict the future we must rely on the best available evidence of what future conditions will be.

---

1. Koontz, Harold, O'Donnell, Cyril, Principles of Management. McGraw Hill Ltd., New York, 1964, p. 70.

2. Moore, Franklin G., Management: Organization and Practice, Harper Row Publishers, New York, 1964, p. 163.

For spectrum planning two types of knowledge or estimation are required.

(a) Predictions of the future demand for radio usage at any point in time, in any region or locality, categorized by type of use.

(b) Prediction of the future technology which will become available to extend or make more efficient the utilization of radio spectrum, at any point in the future. As well, estimates of the economic costs of developing and using technical advances should be made.

With premises (a) and (b) outlined above, a plan of band allocation may be devised. To be sure, time will probably prove it to be inadequate since our premises will not always hold true. Therefore as events turn out to be other than expected with the passage of time, the following principle must be observed.

1.1.2.2 Flexibility

All plans must be flexible if they are to be useful. When conditions begin to depart from expectations, adjustments should be made to make the plan conform to the reality of the environment rather than attempting to force the environment to fit the plan. In other words, entropy will inevitably creep into the situation and we must adjust to exclude or minimize its effects.

The critical factor in flexibility is timing. The earlier adjustments are made to changing reality, the greater the probability of minimizing or excluding the entropy effects.

1.1.2.3 Conclusion

Good band allocation planning will ensure the best allocation of radio spectrum for the good of the Canadian people at all points in time and in all regions and localities. This can only be achieved, however, by the best possible inputs of premises to the planning process and the maintenance of a high degree of flexibility in adjusting to environmental changes. If the premises are poor or flexibility limited, entropy will occur in the form of congestion; economic and social costs will ensue which otherwise might have been avoided.

1.1.3 The Units of Planning

Historically band allocations have been made in Canada on a national basis.[1]

If conditions of demand for spectrum utilization are identical in all regions and localities of the nation the national unit of planning is justifiable. Unfortunately, demand conditions for spectrum use are generally different in all regions or localities.

The principle of flexibility in planning to meet conditions of reality, forces us to conclude that, within technical constraints, a smaller unit of band allocation planning is required. This smaller unit of planning can be achieved in two ways.[2]

---

1. International constraints are discussed in Section 1.1.4
2. Further discusssion is found in Section 1.2.1

(a) Have national allocations but allow variances in different regions or localities where conditions are different.

(b) Use regional or local units as the basis of band allocations.

Deciding which of these two alternative approaches is better requires information about demand conditions, technical, and international constraints.[1]

Although the first approach may be simpler to administer, the second may have more merit because it will tend to achieve better adaptation of allocation plans to reality.

1.1.4 External Constraints on Planning

The discussion in the foregoing sections has assumed that Canada is free to make any decision with respect to the allocation of the radio spectrum. Unfortunately this is not the case. Radio waves are international in nature and joint planning with other countries is necessary to eliminate possible interference. There are three levels of constraints on band allocation: (1) worldwide agreements, (2) international Region 2 agreements; and (3) bilateral U.S.-Canadian agreements.

The International Telecommunications Union (ITU) of the United Nations deals with universal allocation problems. Their decisions are based on inputs from the 125 or so countries forming this union. Arguments for reallocating frequencies to new users or uses must be well substantiated, and cannot be made instantly.

---

1. This is a term of reference for Telecommission Study 2(h).

Even if the allocations are not made worldwide by the ITU, then they are at least standardized over a substantial area of the world. Canada is in Region 2 which consists generally of North and South America, Greenland, and the waters adjacent to these lands. These standarized band allocations are essential if harmful interference is to be avoided. From this point of view, band allocations are desirable. From an economic point of view, international band allocation is also advantageous. Mass production of equipment can easily be undertaken for both domestic and foreign markets once a specific band has been allocated. This design of equipment, however, also has a tendency to lock-in the use of a band to a particular function, and makes reallocation of a band a severe economic consideration if much equipment has to be discarded.

It has been stressed by several people to whom we have talked that there is no frequency spectrum shortage in Canada, and there is no foreseeable shortage over the next decade or so. The bands talked of as being most congested are the mobile band at 150 MHz, microwave bands around major cities, some broadcasting bands, power line carrier frequencies, West Coast maritime bands, etc. The problem does not seem to be acute, the argument goes, since other bands are available for mobile and broadcasting usage, and most microwave systems seem to be working at about 20% of their capacity. Accordingly, new users can be easily accommodated. But the problem will still be with us and, in fact, spectrum crowding and scarcity in some bands is not a domestic problem. It is continental in nature.

The United States is undoubtedly the highest user (in terms of numbers of assignments) in the world. Because of the close proximity of the majority of Canada's population to the US border, and the international nature of radio waves, both countries have defined an area about 75 miles wide in which co-ordination procedures have been developed for practically all frequency bands and uses above 30 MHz[1]. If a taxi company in Buffalo, for instance, requested a mobile frequency assignment, the actual frequency allocated would be one agreed upon by both the DOC and the FCC. It may be possible for Canada to say there is no problem, but the problem exists in the United States.

The United States will likely reallocate some of their spectrum space to accommodate users. In so doing, they will change the nature of some band allocations. This change <u>will</u> affect Canada, and the DOC must be prepared for the proposed change. In fact, they must be prepared in advance, having sufficient knowledge about the problem that they can make counter recommendations if necessary. The International Branch of the department must have access to the latest information, both technical and economic, in order to adequately assess any changes in allocations by the US. Similarly, if Canadian requirements change, agreements with the US must also be effected. These allocations must then be approved by the ITU to preserve an orderly communication system worldwide.

---

1. 600 miles for lower frequencies (30 to 50 MHz), 35 miles for line-of-sight microwave.

In conclusion, international constraints may in some cases exclude an otherwise excellent band allocation plan from consideration. Such constraints, however, must be viewed as fixed unless a manner is found to make the rest of the world march to Canada's tune.

1.2 POSSIBLE CONDITIONS OF THE SUPPLY OF AND DEMAND FOR SPECTRUM

This section of Chapter 1 is based on the assumption that a band allocation plan exists. Given this allocation plan, we will consider, for any point in time and for any region or locality:

(1) what possible relationships between the demand and supply of frequencies can exist;

(2) what alternatives for dealing with these possible conditions are available and applicable; and,

(3) what economic factors are relevant to each of the identified alternatives.

A note of caution is required before proceeding with the remainder of this section. The economic values, with which we are concerned, do not include social benefits or costs which may accrue to the Canadian people from spectrum usage. Only the monetary values which affect the users and the monetary costs incurred are considered. Side effects or externalities of spectrum usage (differences between social benefits and social costs, and private benefits and private costs) are discussed in Section 4.3.2.3.1. of Chapter 4.

1.2.1. The Supply of Available Frequency Assignments Exceeds the Demand for Them

This appears to be the current state of affairs with a few exceptions.[1]

---

1. Possible exceptions may be the 150 MHz mobile Band, Mircrowave bands in urban areas, West Coast maritime usage, and in power line carrier frequencies in the 30 to 200 kHz Band.

The comments received by the study group from users and representatives of the Department of Communications would also lead to the conclusion that congestion or crowding in spectrum bands was not expected to be a serious problem in the near future. For example, there is said to be much available space for land mobile usage in the 450 MHz band so in essence we can conclude that the supply of frequencies for land mobile usage will be adequate for some reasonable period at time.

When there is an excess of supply over demand two alternatives are available:

(1) do nothing; and,

(2) encourage more spectrum utilization.

The first of these requires no discussion. If it is decided (for social reasons) that more utilization should be encouraged the following discussion applies.[1]

The economics associated with an excess supply of frequency assignments, regardless of the form or system of allocation (price mechanism; allocation by fiat) are found in the following logic.

> All users or potential users who consider the price they have to pay (capital and operating costs) for spectrum usage to be less than or at most equal to the economic (monetary) value gained by spectrum use will, by rational economic judgment, be willing to incur the costs associated with use. Conversely, all users or potential users who find the price of spectrum usage (capital and operating costs) greater than the economic value gained by its use will, by rational economic judgment, be unwilling to use spectrum.

---

1. Refer to Terms of Reference (f) and (g) on page iv.

The only exception to the above occurs when a potential user is uninformed about the benefits of spectrum usage. If he were knowledgeable he would be willing to pay the current cost of a radio communication system.

These conclusions provide two basic alternatives for encouraging the use of spectrum.

(a) Lower the cost of Spectrum Usage

(b) Promote the benefits of spectrum usage to pick up new users with the existing price structure who previously did not recognize the real relationship between spectrum benefits and costs.

Each of these is discussed in turn.

1.2.1.1 Lowering the Cost of Spectrum Usage

There are two alternatives for lowering the cost of spectrum:

(1) adjustment of license fees to lower or negative values; and,

(2) adjustment of technical requirements to achieve a lower total cost for spectrum usage.

1.2.1.1.1 Adjusting License Fees

Currently the license fees for spectrum usage are less than the cost incurred by the Department of Communications in making spectrum available and policing its usage (management, standards, monitoring, interference correction, etc.).[1]

---

1. Our discussions with members of the Department of Communications lead us to believe that license fees amount to approximately one third of the Department's costs.

It is possible to categorize the range of license fees as follows:

(1) price (license fee) greater than the cost of its provision and and management;

(2) price (license fee) equal to the cost of its provision and management;

(3) price (license fee) less than the cost of its provision and management; and,

(4) price (license fee) negative (subsidy) where the user is paid to use spectrum.

Two terms of reference of this study deal with the encouragement of spectrum usage: in isolated areas of the nation[1]; and, for new radio services[2]. This encouragement, in a situation of excess supply of frequencies over demand for them, can be achieved by setting the price of spectrum usage equal to or less than the economic value the potential user feels he would receive from such spectrum usage. It is probable that, in most instances, the price category required for such encouragement (without changing standards) would be (4) - a negative price (subsidy). The magnitude of negative price (subsidy) required is dependent upon the potential user's evaluation of the economic value he will receive from spectrum usage. All cases will be different. The size of negative price is also dependent upon governmental policy with respect to the degree spectrum usage should be encouraged.[3]

Negative prices for spectrum rights implies non-existent or low economic

---

1. Refer to Term of Reference (f) on page iv.
2. Refer to Term of Reference (g) on page iv.
3. Refer to Term of Reference (a) second part on page iii.

value for spectrum usage and therefore the benefits must be assumed to be non-economic (social-political). Since, in general, this study is concerned with the economic aspects of spectrum, discussion of the non-economic benefits accruing from spectrum usage, (which would be dominant in determination of the degree of negative price) are not discussed in this report. Secondly, such non-economic judgments must be determined before estimates could be made of the magnitude of negative price required to achieve the degree of usage of spectrum desired.

A final consideration in the encouragement of spectrum usage through low or negative prices, is the effect of the form of the subsidy upon spectrum utilization. There are several ways in which negative prices could be administered and it is desirable that resource allocation distortions caused by the form of subsidy be minimized.

If a subsidy were paid that varied directly with the amount of spectrum used, subsidized users would be encouraged to use all the spectrum they could, even if it meant using technically inappropriate ancilliary equipment. These subsidized users would be encouraged to use equipment that was extravagant with spectrum space. A better form of subsidy would be to pay a fraction of the user's total communications cost so as not to incur distortions; the fraction to be paid would depend on the magnitude of the increased communications capacity desired. Different potential users of additional communications facilities will be induced to buy the systems at different levels of subsidy. The proportion of the cost to

be paid by the government would ideally be that portion that just induces the last required user to decide to "go for" the communication facility.

Difficulties in estimating the amount of subsidy that would just induce each potential additional user to opt for the communication system suggest that a uniform subsidy within a given region would be administratively more convenient.

1.2.1.1.2 Relaxing Technical Requirements

A second alternative for lowering the total cost of spectrum is to relax technical requirements or standards so that capital costs of spectrum usage are lower, thus encouraging spectrum utilization. Two types of standards relaxation present themselves.

(a) Allow substandard equipment with lower costs.

(b) Allow users to utilize a frequency for a purpose different from that specified for the band.

Alternative (a) seems a reasonable policy in so far as it can be achieved without causing interference to other users. In the isolated areas of Canada this form of encouragement would probably be feasible. It is only reasonable that the user be required to bear any risks that may be associated with the use of substandard equipment: e.g., (1) poorer quality communication; and/or (2) a chance that as conditions change and new users arrive he may be forced to upgrade.

Alternative (b) will arise less frequently. Presently, however, the DOC has permitted the use of frequencies in the 450 Mhz land mobile band for radio relay systems in isolated areas. This relaxation permitted the user to substantially reduce his capital costs. The use of microwave frequencies would have been more costly because more expensive radio equipment, antennas and supporting towers would have been necessary.

Relaxation of standards is most certainly a good policy when it doesn't cost (economic or social) anything (no entropy). It is most definitely in agreement with the principle of "Flexibility" in band allocation planning. A restraint on its implementation must be that when conditions change the standards must be altered. This is also consistent with the principle of flexibility.

1.2.1.2 Promoting Spectrum Benefits

It is reasonable to assume that imperfect knowledge about the economic and social benefits of spectrum usage exists. Thus there would be potential users who, if they completely understood the benefits, would choose to utilize spectrum at its present total cost (equipment and license). In order to encourage the use of spectrum these potential users must be informed of the real benefits they would receive from its use.

This logic suggests that an alternative for encouraging the use of spectrum is the development of a good educational and promotional campaign to decrease the amount of ignorance about the benefits of spectrum usage. To the degree such a promotional campaign persuaded some potential users that the benefits of spectrum

usage are greater than the cost they would incur, spectrum utilization will be encouraged.

1.2.1.3 Conclusions: Supply Exceeds Demand

When the supply of available frequencies exceeds the demand for them, at any point in time and/or in any region or locality, the plan must be okay (at least at that time or in that region) since no problems are being encountered.

When this situation occurs, a policy question must be answered; do we want to encourage greater spectrum utilization? If the answer is 'No' then no action will be required. If the answer is 'Yes', the following alternatives present themselves.

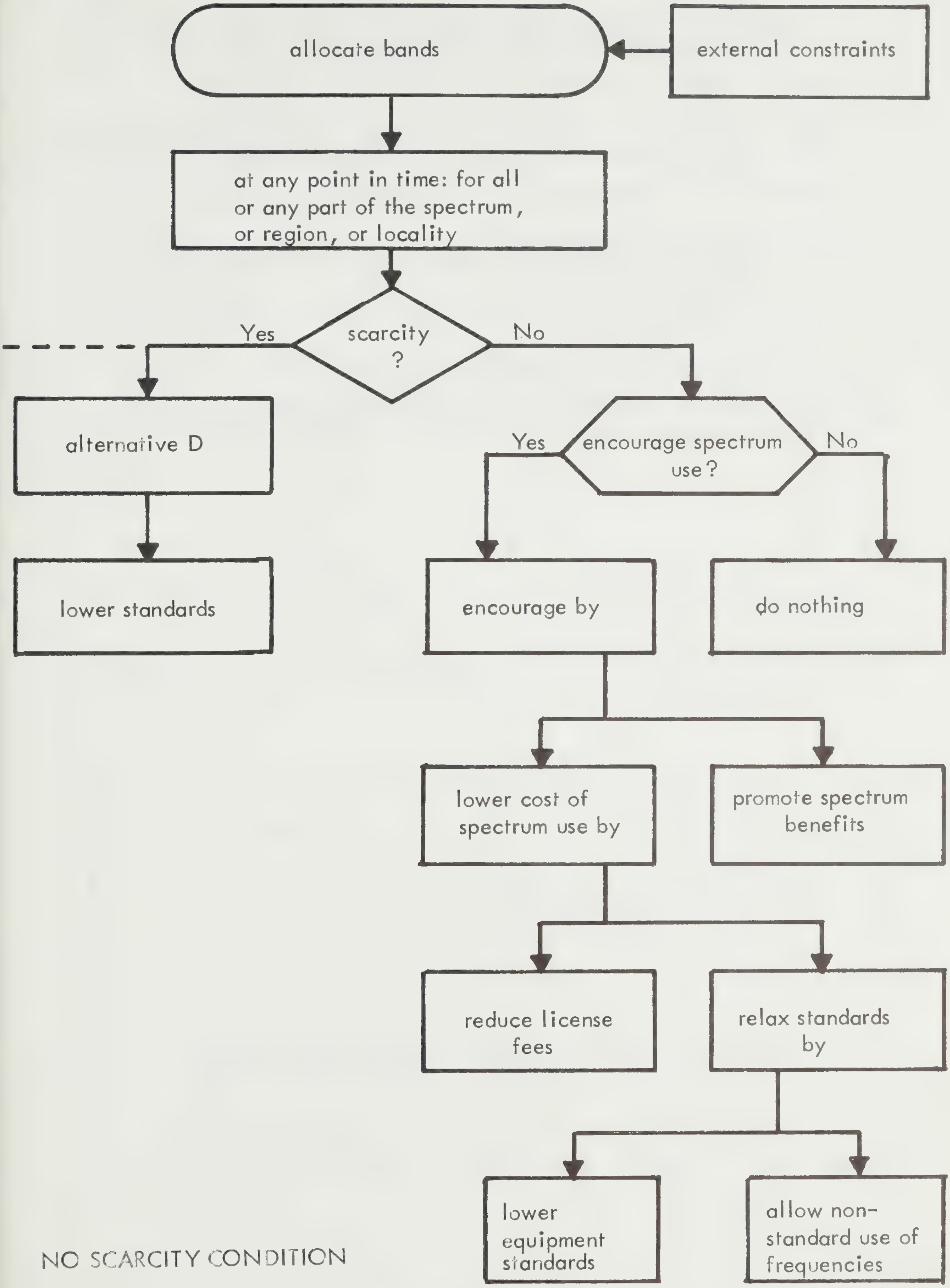
(a) Lower the Cost of Spectrum

(a_1) Adjust license fees downwards

(a_2) Relax technical standards

(b) Promote Spectrum benefits.

A Flow Chart of alternatives applicable to a Non-Scarcity condition and a Decision-Tree of its implementation are found on the following two pages.



NO SCARCITY CONDITION

DECISION TREE - NO SCARCITY

1. Decide whether spectrum use will be encouraged.

2. If yes: decide to what degree and by what method as shown on Flow Chart.

3. Implement your best social and political choice.

1.2.2 The Demand for Frequency Assignments Exceeds the Supply

At any point in time, and/or in any region or locality, (under a given band allocation plan), the demand for spectrum may exceed the supply of available frequencies. Our discussions with spectrum users and representatives of the Department of Communications indicate that this situation is not generally encountered today in Canada. Our terms of reference, however, require that we deal with this eventuality. Recent experience and projected trends in the demand for spectrum indicate that excess demand is a likely condition in the future.

1.2.2.1 The Alternatives

When situations of excess demand over supply are encountered, four alternatives, which may be implemented singly or in combination, present themselves.

A. Band Reallocation

Admit that the band allocation plan did not successfully predict events, nor did it maintain a sufficient degree of flexibility, and on the basis of updated premises and predictions, reallocate the bands.

B. Extend Usable Spectrum Space and/or the Efficiency of its Utilization Through Technology

By applying new technology (at some cost) increase the supply of usable spectrum and/or the efficiency of its utilization.

C. Exclude Users on the Basis of their Economic Value for Spectrum Use

On the basis of the different economic value (benefit) obtained from spectrum use, achieved by different users, exclude those whose benefits are small.

D. Lower the Quality: Allow more Interference

Accept new user even though the quality of communication will decrease because of heightened interference problems.

Alternative D. will be discussed in the remainder of this section. Because alternatives A., B. and C. are more complex and require more extensive treatment, each is provided a separate chapter of this report. Alternative A., Band Reallocation, is discussed in Chapter 2. Alternative B., Changing Technology and Standards is discussed in Chapter 3. Alternative C., Excluding Users on the Basis of Economic Value of Use, is discussed in Chapter 4.

1.2.2.2 Alternative D. Lower the Quality: Allow more Interference

Although some may judge this alternative to be undesirable, for non-economic reasons, there may well be situations where, economically, this would be the best alternative to employ.

When demand exceeds supply, allowing new users spectrum rights implies that greater interference levels will be experienced. Users may or may not find these new levels of interference acceptable. Three types of situations can occur.

(a) The user experiencing increased interference (lower quality communications) may find it has no effect upon the economic benefit he receives from spectrum use.

(b) The user may find his economic benefit has been reduced by higher levels of interference but the benefits still exceed his cost of spectrum use.

(c) The user may find his economic benefit has been reduced by higher levels of interference to such an extent that his costs now exceed the economic benefits.

Therefore, if new users are crowded into the spectrum and all users experience situation (a) no entropy costs have been incurred. No loss in economic benefits to the users or the country will be encountered. If, however, some users experience situation (b) (but not (c)), some economic losses occur. The magnitude of these losses, which we will call Type I losses, should be compared to the foregone revenues of not allowing the new users to employ spectrum (these foregone revenues we call Type II losses). If Type I losses are greater than Type II losses, their difference is the cost of this alternative for solving the excess demand problem. This cost should be compared to the costs of Alternatives A., B. and C. The alternative with the lowest cost should be chosen.

Finally if users experience condition (c) from a lowering of standards the difference between these Type I losses and the Type II losses (benefits foregone by excluding additional users) is the cost of employing the lowering of standards alternative. Again this must be compared to the cost of A., B. and C. solutions to excess demand.

In conclusion, the lowering of standards is a viable alternative for solving a problem of excess demand. It should only be chosen however, when the economic costs of this solution are less than the costs which would be encountered for any of the three other alternatives; reallocating bands, applying technology, and excluding users on the basis of the economic value they receive from spectrum.

A decision-tree for this alternative for dealing with excess demand is found on the following page, while its relationship to the excess supply condition is found on the flow-chart on page 21.

DECISION TREE - LOWERING QUALITY: ALLOW MORE INTERFERENCE

1. Estimate the costs of employing this solution: The difference between Type I and Type II losses.

↓

2. Compare cost with alternatives A, B and C and if lower, implement.

CHAPTER 2

BAND REALLOCATION

[Alternative A.]

The discussion of the reallocation solution to excess demand can be made brief for two reasons. First, the principles of band allocation have been discussed in Chapter 1, Section 1.1, and it would be redundant to repeat them here. Second, the economic considerations which are involved with the reallocation solution are conceptually simple and require no extensive discussion.

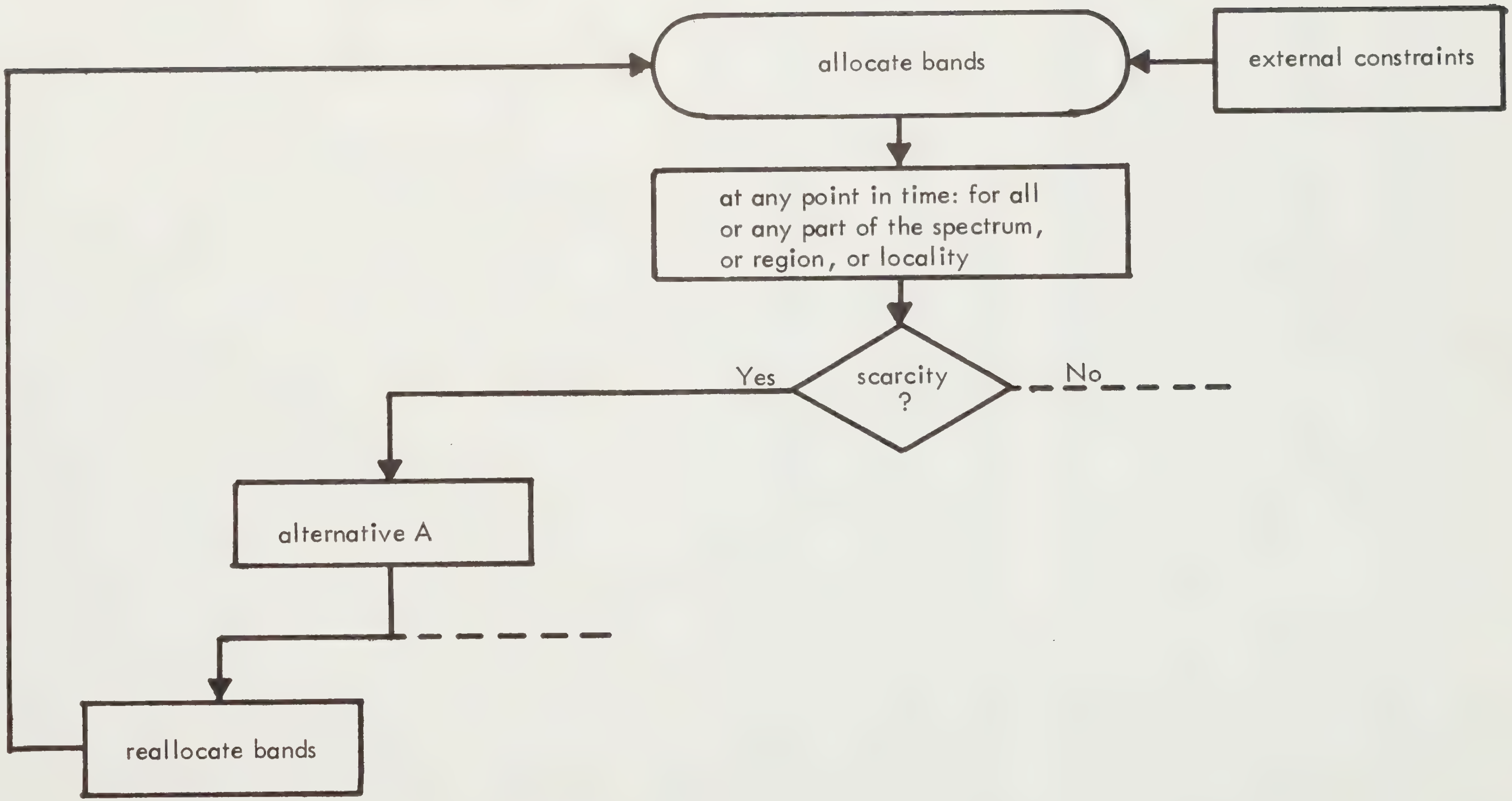
This chapter is organized into 2 sections: (1) procedure and inputs required for band reallocation; and, (2) a scheme for handling the costs of reallocation.

2.1 Procedure and Inputs Required for Band Reallocation

With an understanding of the principles of planning (Chapter 1, Section 1.1) the following steps and kinds of information are required to reallocate the Bands.

Within the international and Region 2 constraints, and known technological constraints, follow the Flow Chart and the procedure of the Decision-Tree on the next two pages.

BAND REALLOCATION



Decision-Tree - Band Reallocation

1. Inputs

   (a) Determine the current state of spectrum utilization for all bands by type of use, in all regions and localities.

   (b) On the basis of the best information available, predict the technological advances which are, or will become available to increase the supply of usable spectrum.

   (c) On the basis of the best information available, predict the future demand for spectrum space by type of use for all regions and localities.

2. On the basis of (a), (b) and (c) above, develop a reassignment of bands which achieves the best fit with current and expected events and also preserves the highest possible degree of flexibility should events turn out differently than expected.

3. Determine the costs that will be incurred: (1) through any adjustments in equipment, required of users, to meet the requirements of the new plan; (2) for research and development required to implement the plan; and, (3) for the Department of Communications to administer the implementation of the plan.

4. If the costs of reallocation are less than alternatives B, C and D choose reallocation as the solution to excess demand.

5. If A is the least expensive alternative, devise a scheme for apportioning the costs of the reallocation.

It is beyond the terms of reference of this study to provide the inputs of (a), (b) and (c) [1]. Without these inputs (2) and (3) cannot be accomplished. Until (3) is known (4) cannot be accomplished. Therefore we cannot discuss band reallocation further at this point. We will, however, address ourselves to (5), apportioning the costs of reallocation, as it is not dependent on the previous steps.

---

1. We understand the (a), (b) and (c) are part of the terms of reference of Telecommission Study 2(h). Therefore their findings can be considered as inputs to the integrated plan presented in this report.

2.2 Apportioning the Costs of Band Reallocation [1]

Since costs incurred by band reallocation are entropy costs, it does not follow that those who stand to gain from the reallocation should bear the cost. Entropy costs provide no benefits. They are dysfunctional and could have been avoided if it were possible to predict the future accurately. It is desirable, therefore, to find some other rationale which provides a basis for apportioning these costs.

A philosophy which may provide a basis for apportioning these costs is found in the following logic:

> Costs of reallocation are entropy costs. They are incurred because a band allocation plan did not adequately predict future events nor adjust flexibly to changing conditions in time to prevent entropy from occurring. We cannot blame the spectrum managers since no man can predict the future. Since the future is unpredictable, we need an insurance scheme which shares the risks associated with such unpredictability. Such sharing of risk reduces the size of economic burden we may have to shoulder at any point in time.

Some few users may be willing to bear these risks rather than participate in an insurance scheme but generally we think most users would not. Therefore, most users will probably assent to the idea of an insurance premium to build a fund out of which reallocation costs would be payed. As an example, a $10.00 per year/per license insurance premium would provide $2,000,000 per year to such a fund with 200,000 issued licenses.

---

1. Refer to Term of Reference (e) on page iii.

This insurance concept, to spread the risks of entropy costs such as reallocation, applies equally well to the costs of interference correction [1] and applying technology as a solution to excess demand. [2]

It may be desirable to specify a maximum size for such a fund. When this maximum is reached, the insurance premiums could be discontinued. Alternatively, the premiums could be continued (perhaps at a reduced level) and the excess funds could be used for research and development in communications or for the subsidization of spectrum usage in isolated areas or for subsidization of new radio services [3].

---

1. Refer to Term of Reference (e) on page iii.
2. Refer to Term of Reference (d) on page iii.
3. Refer to Terms of Reference (f) and (g) on page iv.

CHAPTER 3

EXTEND USEABLE SPECTRUM SPACE AND/OR THE EFFICIENCY OF ITS UTILIZATION THROUGH TECHNOLOGY

[Alternative B]

3.1 Introduction

This chapter presents another major alternative for dealing with excess demand [1]. When there is an excess demand for available frequencies required by some use, the application of technology to the problem can be used to accommodate more users. This type of approach to the excess demand condition provides two alternatives which may be employed singly or in combination.

(a) Increase the Supply of Available Frequencies

Application of technological advances can be used to reduce bandwidth requirements within a band, thereby permitting channels to be spaced closer to each other. Consequently, spectrum space is available to be assigned as a new supply of frequencies. Alternatively, presently unassigned frequencies in the further reaches of the spectrum could be allocated to the use.

(b) Make Efficient Use of a Given Supply of Frequencies

This approach identifies possible techniques for increasing the number of users in a given band by making more efficient use of the frequencies which are presently available.

Each of these approaches is discussed in the light of some current technological advances [2].

---

1. Term of Reference (d) on page iii.

2. It is our understanding that Telecommission Study 2(h) will provide comprehensive information about technological advances. This information will be useful in implementing the decision procedure of this Chapter. Specific advances or areas in which advances may be anticipated are mentioned in this Chapter but they should not be considered an exhaustive identification of technological prospects.

3.2 Increase the Supply of Available Frequencies

When the demand for frequencies for a specific use exceeds the supply more frequencies can be obtained by applying technology in two ways:

(a) by developing further reaches of the spectrum; and

(b) by increasing the supply of frequencies within a band.

3.2.1 Develop Further Reaches of the Spectrum

When a band has become crowded, the demand for spectrum space can be satisfied by offering frequencies in a region of the spectrum that is presently unassigned. Theoretically, the spectrum is infinite, and hence all allocations can be satisfied. Practically, only a limited number of frequencies are available. Though research and development is continually exploiting new reaches of the spectrum, usually only those frequencies just beyond the presently allocated spectrum are being developed [1]. The cost of moving users to these limited number of practical frequency assignments will have to be assessed. The economic considerations of such a move are detailed in section 3.4.

---

1. For example, band allocations have been assigned for all regions of the spectrum up to 40 GHz. Beyond this, no allocations have yet been made. However, extensive research is being conducted in the so-called "sub-millimeter" bands (10-80 GHz) and with lasers in the 100 GHz region of the spectrum. Laser technology is sufficiently advanced that some commercial companies are carrying on extensive experiments to prove out the technical and economic efficiency of carrying communications with lasers. Frequency assignments are therefore a reality in a presently unassigned area of the spectrum.

Research and development in these presently unassigned bands will ultimately permit more users to be accommodated on the spectrum, and accordingly any development which looks promising should be encouraged. In order to evaluate these new developments, the spectrum manager must have access to the best knowledge available from research groups in industry, academic and government agencies. The encouragement of promising developments might also imply that the Department of Communications would initiate some particular research and development through suggestions to their own research laboratories or to other research agencies (or even by direct subsidy to a research group) in order to evaluate the practicability of these new concepts.

We understand that most new developments in this area of the spectrum will be described by other study groups of the Telecommission. This should be the beginning of an extensive data bank of new technological advances which can be used by the spectrum managers as an input to the decision process. The costs involved in research and development should be obtained simultaneously in order to apply the management decisions outlined in this Chapter.

3.2.2 Increasing the Supply of Frequencies Within a Band

Once a band has become crowded it is technically possible to increase the available supply of frequencies within that band by narrowing the bandwidth required for each communicating system within the band. This can be accomplished in two ways:

(a) by improving the equipment, and

(b) by changing the mode of transmission.

Once the individual channel bandwidths have been narrowed, more channels can be accommodated in the same band. The supply of frequencies available for allocation has then been increased.

3.2.2.1 Improving the Equipment

In most bands, equipment standards can be upgraded (for both the transmitter and receiver) by using more selective circuits, better filters, and circuits giving long-term frequency stability. Modifications to present antennas, and new antenna designs can also reduce bandwidth requirements in some regions by reducing spurious emissions which may be cluttering other frequencies. Equipment improvements can be made in either, or both, the electronics and the antennas.

Generally, these improvements imply a higher cost for the equipment; however, newer design concepts (active filters, for instance) using computers as the design aid with their capabilities of handling a large number of parameters, will tend to produce these better circuits at lower cost than present trial and error methods (a necessity with approximations to theory). The advent of solid-state technology in integrated circuit form is also allowing the design of sophisticated, reliable, and more accurately controlled communications equipment.

The use of modern technological advances of these types can produce inexpensive equipment, usually of a better quality (at least at lower frequencies).

Equipment improvements achieved by these approaches may successfully reduce bandwidth requirements. Generally, these improvements will be of the order of a 5 to 10% reduction in the bandwidth required for an individual user. Overall, the band allocation will then have a 5 to 10% increase in the number of possible frequency assignments.

3.2.2.2. Changing the Mode of Transmission

Another technical alternative to increasing the supply of available frequencies within a band (and probably the most effective in terms of the percentage increase in a great many cases) would be to change the mode of transmission. This alternative has been used in the past in two major regions of the spectrum.

The mobile bands (at 150 MHz and 450 MHz) were required, over the past few years, to reduce their bandwidth requirements from 120 kHz to 30 kHz by adopting what is commonly called a "narrow-band FM" transmission mode. (The original 120 kHz bandwidth would be a "wide-band FM" transmission). In so doing, a factor of 4 increase in the useable spectrum space was achieved. The bandwidth in these regions of the spectrum could be further reduced by another factor of two if desired.[1] Alternatively, the FM (or frequency modulation) mode of transmission could be changed to AM (or amplitude modulation) accomplishing a reduction by a factor of 5 over the present 30 kHz bandwidth.

---

1. Equipment has been developed in England using the FM mode which accomplishes this further reduction (15 kHz bandwidth) with equivalent quality.

The fact that one band has traditionally used FM transmission should not preclude the possibility of switching to AM. The quality of the received signal may be less but, for the particular use, the superior quality of FM may not be required. The possibility of changing the mode of transmission should not be overlooked.

Single sideband transmission (SSB) has been introduced in many bands below 30 MHz which were previously operating in a double sideband mode. This change in the mode of transmission effectively doubled the space available for assignments. SSB transmission could be applied to other bands as well.

In some regions of the spectrum, bandwidth compression is a new technology that could be applied to reducing the spectrum space requirements of a user, and hence more channels could be made available. However, in general, bandwidth compression is usually more efficiently used in conjunction with sharing, and accordingly this is discussed in Section 3.3.3.

Most communications are transmitted today using analog signals, and either amplitude or frequency modulation. While these characteristic modes of transmission will be used for a very long time, newer digital techniques are quickly becoming the best way to transmit data, security voice channels, facsimile information, video signals, and similar high quality communications, particularly in the higher frequency regions of the spectrum. The various types of digital transmission (pulse code modulation, frequency keyed shifting, etc.,) offer the prospect of bandwidth savings but usually through a more efficient use of the spectrum. Generally, these techniques are more applicable to the

channel sharing concepts discussed in Section 3.3.3, but in some regions of the spectrum, single-user digital transmission may be attempted. There is a possibility of a saving in bandwidth in such transmission, and this should be evaluated.

Changes in the mode of transmission would generally have to be implemented simultaneously for all users in a given region in order to effect an orderly change-over without severe interference problems. This would probably require specifying an exact time for the changeover, and allowing users to accumulate the necessary equipment in advance. Any change of this nature will incur some costs. If such a change is initiated by the spectrum manager, some of the costs might be borne by the insurance scheme mentioned in Section 2.2.

3.3 Efficient Use of a Given Band or Channel

As an alternative to increasing the supply of frequencies within a band, more users can be accommodated in a given bandwidth by the following three methods. These are:

(a) reduce power radiation,

(b) modify equipment and/or antennas, and

(c) share channels.

The efficient use of a given bandwidth is the area of spectrum management that is receiving the major thrust of technological innovation, particularly in the techniques of sharing with several users. Methods (b) and (c) will tend to have research and development costs associated with them. However, new advances in these areas will add to the data bank of useful knowledge, and the ultimate cost of implementing the changes may be small. Promising developments should

be encouraged, and might be supported through the insurance scheme described in Section 2.2.

3.3.1 Reduce Power Radiation

When an area of spectrum is crowded there is usually a high level of interference. In an attempt to receive a better signal, some users will increase their effective radiated power. (Generally, this power increase must be approved by the licensing agency). This simply causes more interference in the region in terms of intermodulation products, etc. The electrical "noise" in parts of the spectrum may be so severe that some channels are never assigned. The channels are available, but the realities of electromagnetic radiation, harmonic generation by transmitters, and other effects, precludes their use. In an attempt to use all the channels efficiently, the reduction of power radiation by all users in the band would reduce the general level of interference.[1] The reduction of interference should allow more users into the band since the marginal increase in radio noise would be slight if any new user was also required to maintain a low power station.

This technique was effectively used recently in the Montreal area in the 150 MHz land mobile area. A general reduction in the power output of all the users allowed several more users into the band.

Interestingly enough, if all the users in a band adopted digital transmission of signals, the power requirements could be reduced even more, since digital signals are less subject to noise levels. More users could then be accommodated.

---

1. For land mobile communications, this would imply a lower range of signal coverage, but the original range may be retrieved by suitable low power repeater stations. Obviously this would involve a cost to the user in that extra equipment would be required.

Naturally, any change to digital transmission will involve heavy commitments in new equipment.

There is a lower limit to the effectiveness of this alternative, of course. Generally, the power radiated is determined because of a desire to communicate information reliably to a certain region. The same reliability may not be obtained with a reduction in the power radiation.

3.3.2 Modify Equipment and/or Antennas

High levels of interference define what is meant by a crowded spectrum. In some areas of the spectrum, equipment modifications would permit use of unused channels. In the television bands, for instance, improvements in the receivers alone would allow adjacent channel usage within the same geographical area. This would almost double the number of users that could be accommodated. Presently, adjacent channels are not assigned to potential users because the interference between these channels is too high to be acceptable to the viewer. The channels are available, but they are not being used efficiently. The major reason for this state of affairs is poorly selective filters presently used in cheaper receiving sets. There are no stringent regulations requiring more selective circuits in the receiver. Obviously, without such a regulation, a manufacturer will design the cheapest filter possible in order to produce a competitively priced product. In this case, a relatively simple improvement in equipment can offer a potentially more efficient use of the available channels, but the cost of modifying existing sets would be expensive.

Another interference problem commonly encountered is the use of poor filters in the transmitter. The resulting "noise" causes some other channels to fall into

disuse. Improving the equipment will eliminate this cause of interference and more users may then be accommodated. Naturally, some cost is associated with any improvements of the equipment.

In some areas of the spectrum, directional antennas, and antenna sites containing multiple antennas would lead to a more efficient utilization of the spectrum. Specific planning of multiple antenna sites would allow accurate prediction and reduction of interference produced from the various antenna radiation patterns. This approach would probably allow more users to be accommodated than the present relatively random approach of allowing the user to choose his own site. The effect of new users' antenna patterns when added to such a site may now be reliably predicted with the aid of computers[1]. This capability could be used to extend the present capacity of the DOC computer which presently only roughly estimates pattern shapes.

Directional antennas would allow the use of the same channel by several users if they were carefully placed. This concept is useful in some bands, but could not be used in areas where a general overall coverage is required by a user.

Occasionally, interference problems are caused by poorly maintained antenna sites where rusting of the antenna mounts causes spurious radiation. A simple cleaning of the antenna, or bypassing of the joints, will improve the general situation. The lower interference levels which result will allow more users in the band. Obviously locating this problem will require a monitoring function by the spectrum manager.

---

1. Sinclair Radio Laboratories, Toronto, has developed a computer program for this purpose.

With effective monitoring, and sometimes modest equipment improvements, a more efficient use of the available channels within a band can be obtained. The economics involved in adopting any of these alternatives are discussed in Section 3.4.

3.3.3 Sharing a Channel

Many schemes have been proposed for increasing the use, per unit of time, of a given channel. Though other schemes are possible, including combinations of those given below, the following list is illustrative:

(a) Time Division Multiplexing (TDM)

(b) Digital Coding of Messages (Coding)

(c) Simple User Sharing

(d) Priority Messages through a Queueing Theory Approach (Priority)

(e) Orthogonal Transmission

(f) Bandwidth Compression

(g) Utilizing Propagation Data

Many of these channel sharing techniques use digital transmission concepts. The transmission of digital data generally implies a large bandwidth. This may seem wasteful of spectrum space, but generally more information can be carried in the allotted bandwidth than splitting it up into several channels each having a smaller bandwidth. With appropriate coding, messages can be sent to a multitude of users in a shared channel using digital transmission without interference. The message is received only by the appropriately coded receivers. Digital transmission may in fact make the channel concept as we now know it obsolete, perhaps requiring licensing changes.

Bandwidth compression techniques ((f) above) are designed to eliminate redundancy in information that is to be transmitted. As the name suggests, less bandwidth is required to transmit the same information. However, in order to use the technique effectively, several messages, all of which have been compressed, are transmitted over the original channel. A more efficient use of the channel is thereby obtained.

Most of the techniques of channel sharing are designed to provide an optimal mix of users in a band at any one time. The reasoning is that by sharing channels equally amongst users (generally based on the time usage), a more efficient use of the available supply of frequencies is obtained. Technically, it is possible to measure the time duration of messages, and arrange channel sharing appropriately.[1] Problems occur, however, when the quality or importance of a message has to be evaluated in order to give priority to a message. Determining the <u>quality of a message</u> in terms of its economic value to a user should be distinguished from the <u>technical quality of a signal</u>. A detailed discussion of the quality of messages is covered in Section 4.2.2.

The problems of determining the importance of a message seem to be being undertaken in an experimental program being conducted by the FCC in the United States. A task force is presently evaluating a time-shared system for the land mobile bands in Chicago. The channel sharing scheme employs extensive monitoring and priority message evaluation to determine who gets to use the spectrum at a given

---

1. It has been suggested at some meetings that a record of the quantity of messages gives a measure of the value of the spectrum to a user. In fact, some carriers charge customers by time usage, or the quantity of messages, and this is taken to be a measure of spectrum value. Actually, all one can really conclude is that most users who are willing to pay on a quantity basis are probably receiving a higher economic value (return) than the cost of the service. This point is discussed further in Section 4.2.1. and Appendix A.

instant. In this case, extensive management costs are incurred.

The use of propagation data (the effects of atmospheric conditions on the propagation of radio waves at certain frequencies in the spectrum) to maximize the probability of receiving signals at all times during the year is employed in communications to Canada's north. The unique propagation characteristics over our nothern regions are well documented, and computer programs are available that predict the best frequencies to use at any time during the year. Instead of assigning a fixed frequency to one user, several frequencies are shared by a group of users. The users switch frequencies amongst themselves depending upon the computer predictions for that frequency's probable propagation. Users usually receive the best frequency for their message transmission. Hence, method (g) above is a possible channel sharing technique permitting a more efficient use of the spectrum.

3.4 Economic Considerations

The economic aspects of technological alternatives for dealing with excess demand are of two types.

(a) Those costs incurred to make the technology a feasible reality (R and D).

(b) Those costs which would be incurred in implementing the changes required by any of these technical alternatives:

  (b_1) capital costs of users to adjust to new requirements;

  (b_2) the administrative costs of the Department of Communications incurred in managing the spectrum.

Therefore, the cost of any one or all of these alternatives is the sum of

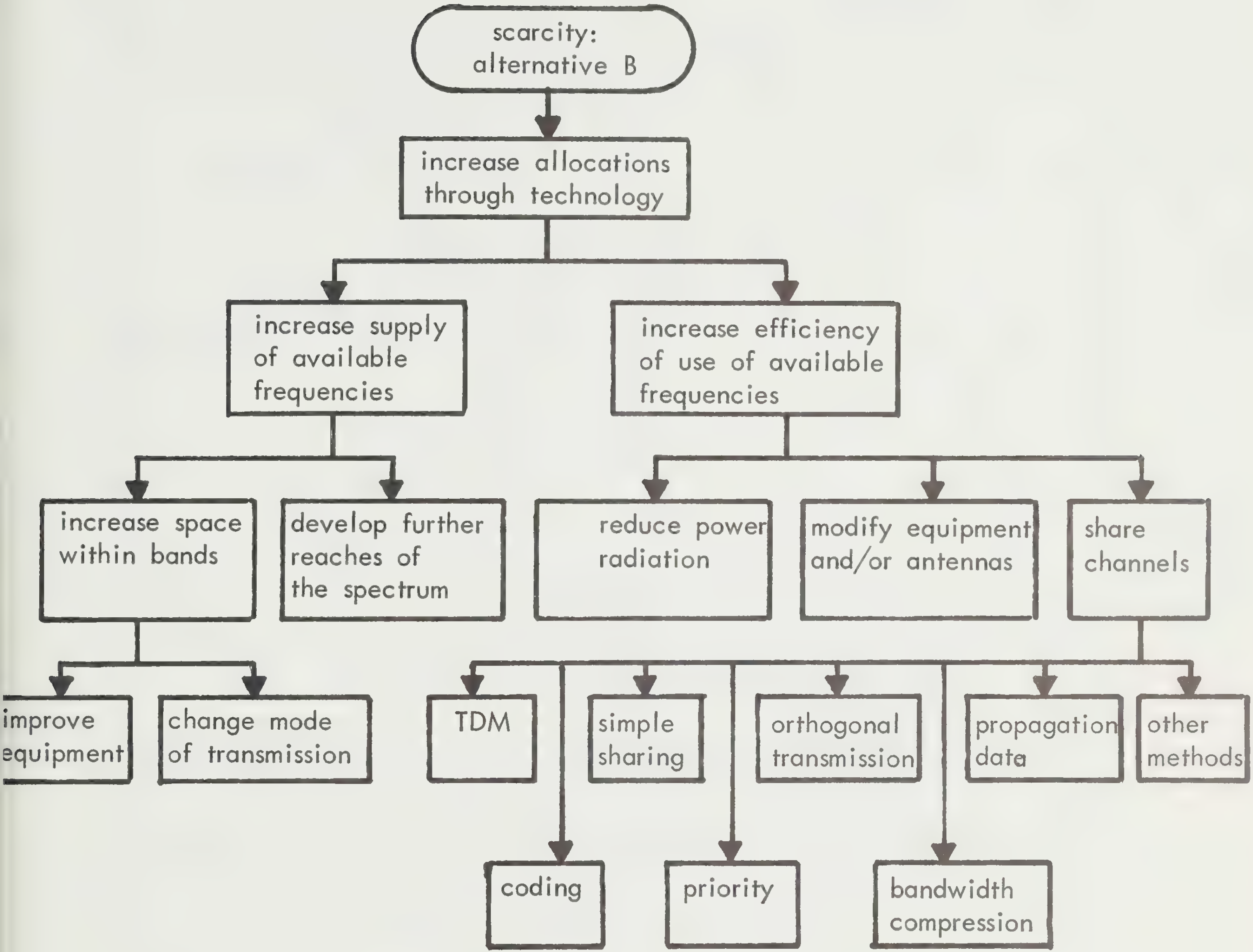
research and development, user capital adjustments, and Department of Communications administrative costs. These costs must be calculated or estimated and compared to alternatives to decide upon the desirability of this approach to the problem of excess demand.

3.5 Conclusion

Many alternatives for dealing with excess demand are provided by the application of technology. In order to determine the best solution, the costs of each technological solution must be compared to identify the cheapest alternative. Then the cost of this best alternative must be compared with the costs of Alternatives A, C and D. If it is lower, it is the best available solution to the problem of excess demand.

A Flow Chart and Decision Tree applicable for this approach to the excess demand condition are found on the following two pages.

TECHNOLOGY


scarcity: alternative B
increase allocations through technology
increase supply of available frequencies
increase efficiency of use of available frequencies
increase space within bands
develop further reaches of the spectrum
reduce power radiation
modify equipment and/or antennas
share channels
improve equipment
change mode of transmission
TDM
simple sharing
orthogonal transmission
propagation data
other methods
coding
priority
bandwidth compression

Decision Tree - Extend Space and Use Through Technology

1. Alternatives

(a) Increase Supply of Available Frequencies

a_1 Develop further reaches of the spectrum

a_2 Increase space within bands

a_{2i} improve equipment

a_{2ii} change mode of transmission

(b) Increase Efficiency of Bandwidth Use

b_1 Reduce power radiation

b_2 Modify equipment and/or antennas

b_3 Share channels (following methods or others)

b_{3i} TDM

b_{3ii} coding

b_{3iii} simple sharing

b_{3iv} priority sharing

b_{3v} orthogonal transmission

b_{3vi} bandwidth compression

b_{3vii} propagation data

↓

2. Estimate cost of each alternative:
R & D, plus user capital cost, plus D.O.C. costs (management).

↓

3. Compare the costs of each alternative to identify the least costly.

↓

4. Compare identified lowest cost alternative with the costs of alternatives <u>A</u>, <u>C</u> and <u>D</u>. If lower, implement.

CHAPTER 4

THE ECONOMIC VALUE OF SPECTRUM USAGE

[Alternative C]

Three alternatives for dealing with an excess of demand over supply have been discussed in the previous parts of this report. This chapter considers the fourth and last alternative; excluding users on the basis of economic value for spectrum usage. Our discussion of this alternative is divided into four sections.

(1) Assumptions and Rationale

(2) Possible Criteria of Economic Value

(3) Alternative Methods of Measuring Economic Value

(4) The Relative Value Concept: How to Use Economic Value to Exclude Users.

4.1 Assumptions and Rationale

Term of reference (b) on page iii set out a major objective of this study; to "determine what economic guidelines, based on sound technical considerations, are available to relieve congestion either existing or anticipated on the radio spectrum". Since this directive does not include reference to guidelines other than economic (social, political, cultural, etc.), this discussion proceeds without reference to them. As has been previously mentioned, we do not deny the existence of such other guidelines or factors but discuss them separately in Chapter 4, Section 4.3.2.3.1. In order to fulfill the directive of (b), therefore, we will assume (for the purposes at hand) that the economic value of spectrum usage can be used as the sole measure of the total value of spectrum usage.

A second factor which must be considered before proceeding to the task at hand is to clarify the position of the so-called "Essential Services". Police, fire, ambulance, and government users of spectrum differ from "commercial" users in that their budgets are generally determined by social criteria. It is possible to employ some limited forms of cost-benefit analysis to their operations but generally this is not done. Only very modest attempts are made to evaluate their service in terms of the economic benefits derived therefrom. We conclude, therefore, that since the decision to allocate frequencies for use by the "essential services" is not made on the basis of economic values, they must be excluded from the analysis which follows[1]. We emphasize that this discussion is limited to a consideration of economic guidelines to relieve current or anticipated congestion. Finally we assume that the approach of relieving congestion by denying spectrum to those users with the lesser economic benefits from its usage is a politically acceptable alternative. If it is not, the remainder of this chapter is inapplicable.

The following parts of this chapter will attempt to answer the following question: "When allocations of an essential nature have been made in a congested band, how can the economic (not social or otherwise) value of spectrum usage be measured and used to allocate the remaining available frequencies, and what is the cost of this alternative for dealing with a situation of excess demand?"

---

1. Note: This implies that essential services will always be assigned spectrum and that the use of economic criteria to exclude users in situations of excess demands applies only to non-essential users.

4.2 Possible Criteria of Economic Value

What economic values (benefits) do users receive from spectrum utilization? More explicitly we may ask; "is there something we can measure, which is the same as the economic benefit of spectrum usage?" It is necessary to define economic value before we can suggest ways to measure it.

In our discussion with user groups, three possible concepts of economic value were suggested.

(a) The quantity of messages communicated by the user.

(b) The quality (value of content) of messages communicated by the user.

(c) The incremental effect of spectrum usage on the revenue statement of the user.

Each of these is discussed in turn.

4.2.1. Quantity of Communication

The quantity concept of spectrum usage benefit essentially posits that the value is dependent upon the number and length of messages transmitted. It is relatively easy to dismiss this proposition with common sense logic.

(a) Messages have different economic consequences for the sender or receiver even though they may be equal in number or length. For example, a message of 10 seconds duration by a dispatcher for a taxi company may result in approximately \$1.00 to \$5.00 revenue to the company. However, a message of 10 seconds duration by the dispatcher of a cement company may save one load of cement

worth $75.00 which otherwise would have been lost. It is easy to devise examples where the economic disparity is far greater.

(b) Even if the economic value of messages per unit of time were identical, a monitoring system would be required to measure the number and length of each users' messages in order to utilize this concept to allocate frequencies or assess the magnitude of license fees. This procedure is not feasible and therefore denies the utilization of the quantity concept.

We conclude therefore that the quantity concept of economic benefit from spectrum utilization is both invalid and impracticable.

4.2.2 Quality of Communication

The quality concept posits that the economic value of spectrum usage is dependent upon the economic quality (content) of the message transmitted. The validity of this concept cannot be disputed. As our example for the quantity concept demonstrated, each message of a user will have some economic monetary value associated with it. It must be concluded, however, that the quality concept, although valid, is not a measurable concept of economic value for the following reasons.

(a) It is not possible to determine the monetary value of all messages to the user without involving judgmental factors. For example, if the

message is one which allowed the user to avoid an event with monetary consequence (e.g., a power utilities automatic fault correction system) it is necessary to estimate what the events' economic cost would have been if the message had not been communicated - a Herculean task.

b) In order to utilize the quality concept, a monitoring system would be required, not only to measure the number and length of messages transmitted by each user, but also to ascribe a monetary value to each message. This in our view, is not practical.

We must conclude, therefore, that although the quality concept of economic benefit appears valid, it cannot be utilized practically for the purpose of allocating frequencies or assessing license fees.

4.2.3 The Incremental Effect of Spectrum Usage on the Revenue Statement of the User

This concept posits that the value of spectrum usage is equal to the total incremental effect of spectrum usage on the revenue of the user. Expressed differently, a user would be economically rational to pay any cost (price) of spectrum usage (capital and operating costs) up to that value which is just equal to the revenue generated by the use of spectrum. Simply put, the value of spectrum is the revenue that can be earned by its use.

It does not appear possible to fault the validity of this concept. It is, in essence, the sum of the values of each message sent which was shown in the previous

section to be a valid concept. The important question now is; "how can we measure the economic value of spectrum usage expressed as the revenue that is received because of spectrum utilization?" The following sections attempt to identify the alternatives available for this task and assess their practicalities.

4.3. Alternative Methodologies for Measuring Economic Value

We need to measure the economic value of spectrum use achieved by each user. Two basic alternatives present themselves;

(a) Centralized management evaluation (presumably by D.O.C.) to decide the economic value.

(b) Decentralized market mechanism.

4.3.1. Economic Value Determined by Management Decision

Within this approach are two sub approaches;

(a) Direct Assessment of Economic Value:
Raise License Fees.

(b) Indirect Assessment of Economic Value.

4.3.1.1. Direct Assessment of Economic Value: Raise License Fees

When an excess of demand exists, users will be willing to pay a higher price for spectrum use if the cost to them is lower than the economic value they receive from its use. Those users with low economic value from spectrum use will move to alternative systems when the cost is increased. Therefore, for each increase in the license fee, those users who then find the price of spectrum exceeds its benefits will drop out. In order to match demand with supply, the level of license

fees should be raised so that the number of users remaining just equals the supply of available frequencies. This method will always ensure that the highest value users receive the available supply of frequencies.

The cost of this approach to dealing with excess demand is the total of the foregone benefits: i.e. the sum of the economic values for spectrum use of the excluded users minus the sum of the benefits they receive from the next best alternative communication system.

4.3.1.2 Indirect Assessment of Economic Value [1]

If raising license fees is politically unacceptable, there are two ways of indirectly measuring the value of spectrum use and using the values measured to exclude users as required. These are:

(a) Economic value as determined by expert opinion; and,

(b) Experimental simulation of users economic benefits.

4.3.1.2.1 Economic Value as Determined by Expert Opinion

The use of one or several experts to determine the economic value of spectrum usage is perhaps the conceptually simpler alternative. It is, as well, an approach which provides a great number of choices with respect to the composition, structural arrangements and procedures to be employed by the experts. This discussion does not attempt comprehensive coverage of the multitude of ways in which experts may be chosen, structured, and the procedures established for accomplishing their task. Rather we address ourselves to three critical factors which are involved in the

---

1. The concept of measuring the cost of alternative communication systems as a measure of economic value is not a valid concept. See Appendix A.

use of one or several experts to establish the economic value of spectrum.

1. The underlying rationale associated with using experts for such a task.

2. Factors which should be considered in choosing experts.

3. The apparent advantages and disadvantages of this approach.

4.3.1.2.1.1 Rationale

Historically, in Canada, the role of government or centralized agencies in determining or influencing the allocation of economic resources has been minimal compared to countries such as Russia or even Britain. For most resources, we have let the free hand of enterprise determine the development and allocation of resources, under the assumption that private sector benefits are approximately coincident with national economic welfare.

In some cases, centralized authority has played a dominant or even monopolistic role. Examples are such organizations as the CNR, CBC, and government activity in regulating fossil fuel distribution, etc. It appears valid to observe that, when resources of a national nature, or resources critical to the national welfare, are concerned, centralized decision making about its use and allocation are occurring more frequently. In other words, it seems that Canadians utilize and accept the concept of central management of national resources more readily today than was common 25 years ago.

There are two ways in which such centralized management of a national resource occurs.

(a) Legislative Regulation

In this instance, the policy, management, and policing of the use of a national resource is carried out by the existing governmental structure.

(b) Commissions

In this instance, a body of experts is formed to establish policy and manage a national resource. An example of such a body is the CRTC which establishes policy and manages broadcast communications in Canada.

The existence of commissions indicates that the philosophy of using a managerial-intellectual elite for the purpose of framing policy and managing a national resource for the good of all Canadians, is an acceptable and perhaps desirable form of economic organization. To be sure, this philosophy contradicts the philosophy of allowing individual enterprise to allocate resources, but our purpose here is not to judge which of these philosophies is better. Rather, we conclude that since the philosophy of centralized decision making does exist in several sections of the economy, it should not be judged, per se, as unacceptable for managing the allocation of the radio spectrum.

The use of a body of experts to determine the economic value of spectrum usage, would give the experts the power to decide which users would receive assignments in congested bands. In effect, therefore, this approach to relieving congestion suggests the formation of a permanent commission to establish policy, manage, and police the radio spectrum in congested bands.

4.3.1.2.1.2 Choosing the Experts

If a body of experts is used to determine the economic value of spectrum use, we must ask; what qualifications must an individual have to be considered "expert" for this task?

Since the value of spectrum usage has been defined in Section 4.2.3 as "the incremental effect of spectrum usage on the revenue statements of the user", the sole qualification necessary to validate an individual as "expert" must be evidence that he can estimate well the value of such effects for one or several uses of spectrum. For example, if an individual can demonstrate a capability of measuring or knowing the revenue effect of spectrum usage for an oil burner service business or taxi-cab service, he becomes a potential member of the body of experts. Secondly, one individual may qualify as "expert" for more than one type of spectrum use as when a business economist can demonstrate competence in measuring the revenue effect of spectrum usage for several types of users; i.e. power utilities, land mobile users and perhaps common carriers.

A final point should be considered in choosing the experts who would assess the value of spectrum usage. Any expert chosen should be able to demonstrate lack of bias or prejudice towards any particular type of use. Thus ownership, management or consulting relationships with any spectrum user would perhaps be sufficient grounds for disqualifying an individual on the grounds of possible bias.

4.3.1.2.1.3 Conclusions

The use of one or several experts to determine the economic value of spectrum usage is conceptually the simplest alternative. If the experts do a good job, (and there are no guarantees that this is even possible), an equitable and valid basis for choosing which users will receive frequency assignments in congested bands will result. To do this, the experts would probably have to devise an acceptable methodology to measure and rank the economic value of spectrum usage. It is this factor which probably leads to the major disadvantage of this approach. Users denied frequency assignments will probably reject the experts' decisions. Therefore a situation, common to most commissions, of hearings, conflicting evidence, charge and counter-charge would be the order of the day.

There is another disadvantage to this approach. Not all users of the same type will have the same economic value for spectrum usage for a multitude of reasons. Ideally, we would like to measure what each user would pay, at maximum, for spectrum usage rights as the measure of what he feels its use means to his business. A body of experts would probably have to employ (for practical reasons) some standardized methodology of approximating this amount which would fail to take into account the variety of factors influencing any particular user's business. The average measure achieved would not really be accurate for any user because, in general, individual users will not be average. Thus the body of experts approach could probably not take into consideration factors which may

be critical in any individual user's situation.

In conclusion, this approach does not appear potentially useful for measuring the economic value of spectrum usage. It cannot practically take into account the complexity of the problem and its use would probably result in great confusion.

4.3.1.2.2 Experimental Simulation of Users Value for Spectrum

4.3.1.2.2.1 Rationale

The basic philosophy underlying the experimental simulation approach is that the user of spectrum space is the only valid judge of his economic value or benefit from spectrum usage. Each user finds some economic worth in spectrum use. However, the worth will differ between users of the same type and also between different types of use. Secondly, the value of the use may, in principle, be more (surely the usual case) or less, (lack of knowledge about the merit of alternative systems) than the cost of the next best alternative since alternatives cannot guarantee the same level or quality of service provided by spectrum. In other words, both the revenue and expense statements of a business will be affected by each alternative system of communication. Therefore a user will judge the value of spectrum usage for its effects both on revenue and disbursements (including capital costs) and not just on the cost associated with alternative systems of communication. The users' judgments about the value he receives from spectrum usage, therefore, appear to be more valid than an 'alternative cost', or body of experts' approach.

Users are involved with their communication system and its effect on their business. They should be better able to judge the value of spectrum usage than some outside expert not particularly involved with the user's business or that type of usage. The users' judgments of spectrum worth would be most realistically measured by a market system of allocation as discussed in the next section (4.3.2). It is our purpose here, however, to explore and examine methodologies whereby the values established by such a free play of market economics might be approximated through the use of experimental simulation and measurement techniques. Our purpose is to determine if we can measure, under less than realistic conditions, how the user would actually judge the value of spectrum usage in a free market system. In other words, we want to determine if the price a user would pay for spectrum under a market mechanism can be measured by a methodology other than the market mechanism itself.

4.3.1.2.2.2 Potential Application of Experimental Techniques

In the past several years, scientists in the field of experimental psychology have developed a number of techniques which attempt to determine how an individual would behave in a given real life situation. Many difficulties are encountered in this approach. The most crucial are as follows:

(a) Can valid measurements of what an individual would do in a given situation be measured by his choices or behaviour in unrealistic conditions of simulation or laboratory. Many psychologists would raise questions as to the validity of such types of measurement. These qualifications always deal with the degree to which an experimental situation does not incorporate variables which would affect the individual in the real life situation.

(b) A second factor which must be considered is the degree to which the individuals participating in the experiment are conscious or aware of the purpose of the experiment. If users brought into an experimental situation were conscious of the purpose of the experiment, they might attempt to influence the results to their ultimate benefit and therefore the results of the experiment would not be valid. They would "not tell it like it is".

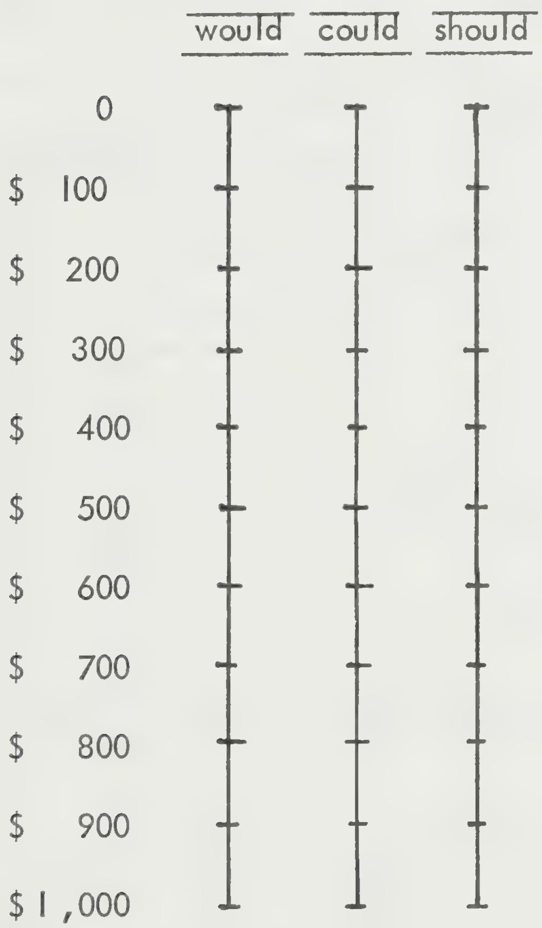
c) A third problem is that users of different types face different kinds of situations with respect to spectrum usage. Therefore, it is necessary to develop a technique which can take the different characteristics of different users into account and still be amenable to generalization.

An approach which might be feasible for measuring the economic value of spectrum usage is called the "point of indifference" approach. In this technique, the individual is given the task of making decisions between values of two alternatives. The thing which is measured is the point at which the individual is just indifferent between specified values of those two alternatives. For radio spectrum, two alternatives which could be ranged before the individual in the experiment would be the factor of giving or providing an assignment of spectrum frequency at various levels of cost to the user.

The value or cost of the spectrum at which the user is just indifferent as to whether he has spectrum or not would then be the value of spectrum to him.

One requirement of this approach is that its purpose be disguised. If the user participating in the experiment could readily see its purpose the validity of the results would be, to say the least, highly suspect. It would be necessary therefore to devise a testing situation in which his answers regarding spectrum would be only one part of the experiment and a great number of other things would be done in the experiment to mislead the respondent as to what the real purpose of the experiment was.

A second type of experimental measurement technique is as follows:



1. What dollar amount would, could, and should you pay for the right to operate a business.

2. What dollar amount would, could, and should you pay for your vehicles.

3. What dollar amount would, could, and should you pay for tires.

4. What dollar amount would, could, and should, you pay for the right to use a voice channel of the radio spectrum.

On the chart above three scales are listed on the left side of the page. These scales are expressed in dollars and consist of a scale for what the individual would be willing to pay, a scale for what he could pay and a scale for what he thought he should pay for a particular item. On the right side of the page are a group of questions of a business nature which the individual would be asked to answer by placing an appropriate mark on each of the three scales. For example, we have questions about what he would, could and should pay for a license to operate a business or for what he would, could or should pay for the tires for his company vehicles and included in this list of questions would be, what he would, could or should pay for the right to use a voice channel on the radio spectrum.

Although this technique may allow us to disguise the purpose of the experiment, it breaks down in that most businesses do not commonly purchase a great number of rights other than the right to use spectrum or the right to operate a business. The only business decisions that land mobile radio users have in common are those associated with their vehicles. Accordingly, it is very difficult to devise a set of questions that is sufficiently diverse and lengthy to disguise the purpose of the experiment.

4.3.1.2.2.3 Conclusions

The advantage of using a technique such as experimental simulation is that the value of spectrum usage expressed in dollars may be established, not on the basis of someone else's opinion, judgment, or measurement of what spectrum is worth to the user but rather upon what the user thinks spectrum is worth to him. It is reasonable to expect therefore that users informed that they will not receive a frequency allocation because they expressed lower values for spectrum usage than other users will have few grounds on which to disagree with the management allocation decision. They will have determined their own fate.

Given the limitation of time, it was not possible to delve more deeply into the development of experimental techniques for measuring the value of spectrum usage. We must conclude, however, after consulting an experimental pychologist, that there is a good potential for perfecting such a technique. It is likely, with more intensified effort by experimental psychologists a technique might be developed which would meet the necessary requirements of applicablity and validity.

In general, this approach to the measurement of the economic value of spectrum usage, [assuming a market system is not politically acceptable] would appear to be better than any previous alternative discussed because it employs the users' judgments of value rather than estimates of what others think his value is.

4.3.2 The Market Mechanism

4.3.2.1 Introduction

The market mechanism, or price system, is another way to reflect economic value of spectrum use. Section (4.3.2.2) deals with the general nature of the price mechanism, its range of applications, the major premises on which it rests, and its advantages as a system of resource allocation. Section (4.3.2.3) discusses the most frequently heard criticisms of the price mechanism with respect to its application to spectrum management. Section (4.3.2.4) deals with the problem of defining property rights in spectrum use and its implications for the price mechanism.

4.3.2.2 Nature and Merit of the Market Mechanism

All societies must and have devised methods for allocating resources because resources are, in varying degrees, scarce. The price mechanism is such a device. Since few, if any, resources are available in superabundent supply, the potential scope for the application of the price mechanism is exceedingly broad. Indeed, ruling out the use of the price mechanism on its face is appropriate only in the case of true public goods. A public good is one where peoples' use of the good (or resource) does not interfere with any other persons' capacity to use or enjoy the good or resource. The list of true public goods, is short and becoming shorter. The traditional examples of air and water are no longer valid in some areas. The early history of radio in the United States makes it perfectly clear that the electromagnetic

spectrum is not a public good as defined above; the chaos resulting from treating it as if it were a public good is a matter of record. Accordingly, the price system has a potential application to the management of the spectrum that warrants exploration.

Before turning to the application of the price mechanism to spectrum management, it will be useful to explore, in a cursory way, the salient premises and advantages underlying the market mechanism. The reason for this stems from our impression that spectrum users and managers tend to see the difficulties of applying the price mechanism (these are discussed in Section 4.3.2.4) more clearly than they see the advantages.

In the Western World, the price mechanism is routinely used to allocate resources, presumably because it is widely believed that, for most allocation problems, the price mechanism is the best alternative available. That there is strong support for this view is indicated generally by the observation that countries that make extensive use of the price mechanism tend to be richer (generally defined by GNP) than countries that do not.

The fundamental principle underlying the price mechanism is a familiar one. Individuals and business firms acting in their own self interest will bid for and receive resources only when the value of the resource to them exceeds its price. The important consequence of this is that, apart from errors of estimation, resources will flow to those who can use them best and automatically adjust to correct such errors of estimation.

Those who believe they can use scarce resources to some advantage but not to a sufficiently great personal advantage to warrant paying the going market price will be denied the resource in question. This is desirable from a social viewpoint in that we want those who can use any specified resources only in a relatively inefficient or unwanted way (compared to alternative uses) to be denied use of the scarce resource. This is not necessarily or even generally true under alternative schemes for allocating resources (e.g. first come - first served, an equal share for all etc.). On the other hand, anyone who wants some quantity of a resource is assured of getting what he wants under the price system (not necessarily or generally true under other schemes) if he is willing and able to pay the going price. In general, he will be willing and able to pay only when he can use the scarce resource to create enough additional value to at least cover its cost.

Assuming richer is better than poorer, society benefits from this process for two main reasons: (a) there is good reason to believe that resources will be allocated with a reasonably high degree of efficiency, and, (b) the price mechanism tends to induce behaviour that makes society richer (as measured, for example, by Gross National Product).

Under the price system, people are encouraged to learn skills and produce goods and services that are valued by others if they are to share the

rewards of economic activity. Under alternative allocation schemes, different behaviour may be induced. If scarce resources are allocated on a first come, first served basis, people will be encouraged to learn to be good at "queuing up". If resources are allocated in equal portions to all, people would not seem to be encouraged to do anything in particular. It should be clear from the above line of discussion that it is not a co-incidence that countries making extensive use of the price mechanism for allocating resources tend to be the richest countries.

The merit of any system of resource allocation can be measured against the benchmark of maximum social value. Maximum social value occurs when there exists no change in the quantity, composition and distribution of output that will increase the total real income of the society. In order for the price mechanism to achieve this elusive condition, a very long list of conditions must be fulfilled. All of these conditions are never fulfilled simultaneously; accordingly, the price system cannot achieve the social optimum. However, lack of perfection is insufficient grounds for rejecting the price mechanism out of hand. The question is not "will the price mechanism allocate resources in a socially optimal way? (the answer must surely be 'no')" but rather, "will the price mechanism come closer to achieving this optimum than alternative allocation schemes?" The answer to this - the relevant question - would seem to be "frequently but not always in the affirmative".

4.3.2.3 Frequently Raised Criticisms of the Market Mechanism

4.3.2.3.1 Externalities

A frequently raised objection to the use of the price mechanism to allocate spectrum space is this: the value to society of use of spectrum for some kinds of application is much greater than the value to the user. Thus, the argument runs, if users were charged a price determined by supply and demand, severe distortions would result due to the disparity between social and private benefits. The supposed disparity is talked of as an'externality'.

Externalities occur when the private benefit accruing to the owner of a resource is not equal to the social benefits or alternatively, the private costs of using a resource are not equal to the social costs. Externalities (also called neighborhood effects) may be negative or positive. Pollution is an obvious example of a negative externality. National defence or police services and possibly education are the standard examples of positive externalities.

For most goods, services or resources, the person who buys them receives all or virtually all of the benefits from them. The reason for this is that his ownership of the good, or service, or resource, tends to preclude others from using it.

We ordinarily ignore externalities (whether positive or negative) for goods and services for which the magnitude of the externality seems to be small, i.e. private benefits adequately approximate social benefits and private costs adequately approximate social costs. This is sensible because the cost of

estimating externalities and the difficulties associated with it would generally use up more resources than would be saved by any resulting improvement in resource allocation.

The price mechanism tends to be a socially inefficient way to allocate when all three of the following conditions prevail: (a) externalities are positive, (b) they are large, and (c) it is difficult to devise a practical plan for collecting through the market mechanism from all who benefit. Defence is a classic example. If national defence (a service) were sold in the market there would be much less of it produced than people want. This is because everyone benefits regardless of who buys it and all would tend to hold back and wait for someone else to buy it. Police service is similar. If I lived next door to you and you bought a service under which your property was patrolled hourly throughout the night, I would benefit (without paying) because the patrolman would tend to deter burglars from entering my property about as much as from entering yours. Everyone would wait for everyone else to buy the service with the result that much less of the service would be provided than was really wanted. As an allocator of resources, the price mechanism breaks down under these conditions.[1]

---

1. Although our discussion centres on positive externalities it should be pointed out that negative externalities are at least as important as positive externalities -- Pollution is perhaps the outstanding example. Under the price system which turns on private costs not social costs we may tend to produce 'too much' of some products like steel, pulp and paper, etc., which have negative externalities. In recent years in this country, we have taken steps to modify the unfettered action of the price mechanism in these situations.

An imaginative and potentially very significant line of argument has appeared in the literature whereby the price mechanism can work to reflect these negative externalities and achieve a close approximation to social costs and benefits - see in particular R. H. Coase - "The Problem of Social Cost", Journal of Law and Economics, 1962.

The existence of large positive externalities in some services readily explains much of government activity in the provision of services. Some services have a value greater than the cost of providing them but profit-seeking firms will be reluctant to provide them unless enough of the benefits can be reaped by them. Where it is impossible or impractical to charge those who benefit from a service, the service will not be forthcoming from the private sector. As Robert Dorfman has put it:

> "Governments rush in where businessmen decline to tread. As a general rule, if a good or service is desirable, it will also be profitable and thus will be provided by private enterprise. But there are important exceptions to this rule. Government initiative is, for example, called for where investments that businessmen would deem unprofitable are socially worthwhile".[1]

4.3.2.3.1.1 Externalities in Communications

It would probably be the judgment of most people that there are externalities in communications and they are, on balance, positive. A couple of examples will perhaps suffice to indicate why this might be so. The terms of reference of this study require the study group to investigate means for increasing communications capabilities in the far north. This directive carries the implicit assumption that we now have too little communication capability there. Without government activity, we can assume as a first approximation, that current capacity reflects the private cost - private benefit relationship.

---

1. Robert Dorfman (ed.) Measuring Benefits of Government Investments, The Brooking Institution, Washington, D.C., 1965, p.4.

If we are to contemplate adding to this, we must believe there are positive externalities. Secondly, spectrum use is subsidized generally, i.e. the revenues from licensing fees cover only about 30% of the operating costs of managing the spectrum. This too carries the implicit assumption of positive externalities. The value to society of communications using spectrum space is anybody's guess. In principle, a cost - benefit analysis could be done but like most cost - benefit analyses, the value of the results would presumably be open to question.

It may be that externalities are positive and equal for all users of the spectrum. Here, the issue of externalities evaporates and the price mechanism would allocate resources properly in the social sense as well as in the private cost - benefit sense. It is unlikely, however, that this simplifying assumption approximates reality. It is far more likely that externalities are substantial for some users and so near zero for others that they can safely be ignored.

4.3.2.3.1.1.1 The Zero Positive Externality Case

For most, if not all, commercial enterprises who use communications systems as an adjunct to their business, the price mechanism for spectrum would appear to cause no distortions of a social value nature.

These users, e.g. taxis, delivery services, etc., fully internalize all the advantages of spectrum and reflect these advantages in lower costs and prices. Where used, spectrum makes the operation more efficient and

the public benefits in the form of lower prices. There are no externalities and thus no distortion resulting from the use of the price mechanism. The price system says it all. Social benefits equal private benefits apart from possible complications raised by the issue of monopoly.

4.3.2.3.1.1.2 Services with Positive Externalities

For some services that use spectrum space, e.g. defence, police, fire etc., positive externalities may well exist. For the reason outlined above, the market mechanism cannot be relied upon to assure that the socially optimal amount of services of these types will be forthcoming. Accordingly it is reasonable to conclude that an alternative to the market mechanism may well be superior.

The usual alternative is some sort of cost - benefit analysis. Estimates of social benefit (essentially the sum of the private economic benefits that exist but cannot be collected for the reasons outlined above, (section 4.3.2.3.1)) are made and compared to the costs involved.

The merit of cost - benefit analysis is open to a considerable range of opinion as revealed in the following quotations:

> "We have begun to grope our way towards a practical concept of economic planning which may prove in a few years time to be as revolutionary in its policy implications as was the Keynsian Revolution in economics thirty years ago. It also originated many years ago with a Cambridge economist - Keynes' contemporary Pigou. It is the concept of social costs and benefits. This leads to the revolutionary concept that we can actually add up the social costs and benefits in money terms by asking what value people would themselves put on them. We can then express them as the rate of return on capital as an ordinary capitalist would and so determine

our investment rationally from the point of view of the community as a whole, just as a capitalist can now do for his private point of view." 1.

Against this view we have a comment by Arthur Smithies:

> "The foregoing discussion leaves us two major conclusions. First, judgment plays such an important role in the estimation of benefit-cost ratios that little significance can be attached to the precise numerical results obtained. Second, competition is likely to drive the agencies toward increasingly optimistic estimates and far from resolving the organizational difficulties, computation of benefit-cost ratios may in fact make them worse". 2.

Notwithstanding the limitations of cost-benefit analysis, assume that we conclude that certain services such as defence, police and fire protection etc., should be offered. It does not follow from this conclusion that spectrum space ought to be provided free of charge to such essential services or even that it should be subsidized. How to produce the service involves economic and technical considerations and the market works well in determining the nature and relative quantities of inputs required to provide the service. If we estimate by cost-benefit analysis (or merely judge intuitively) that fire or police protection should be provided, we pay for the

---

1. P. Hall, Labour's New Frontiers, (London, Andre Deutsch, 1964) p. 173. cited in A.R. Prest and R. Turney "Cost-Benefit Analysis: A Survey". The Economic Journal, no. 300, Dec. 1965 v. LXXV p. 7 & 8.

2. Arthur Smithies, The Budgetary Process in the United States, (C.E.D. Research Story) New York, McGraw-Hill, 1955, cited in Prest and Turney op. cit. p. 7 & 8.

service -- in taxes. There appears to be no special merit in singling out one input (spectrum) to be provided free. Extension of the logic suggests providing cars, trucks, rubber boots, and night sticks free as well. The obvious and general (except for spectrum) approach is to provide a budget (the size of which depends on the outcome of the cost-benefit analysis) and let the agency providing the service buy in the market the inputs it requires to produce the quality and quantity of the service that has been decided upon. The important conclusion of the discussion is that the existence of positive externalities does not provide a reason for giving spectrum space free where it has a value and commands a price. Suspending the price mechanism for some inputs to the provision of an essential service is at best partial and at worst messy and inconvenient.

In short, the argument that spectrum ought to be free and subsidized for services having positive externalities is not valid and has little to commend it from an administrative standpoint. If the price mechanism is ever used to allocate spectrum, it is important that the 'red herring' involved in this commonly raised criticism be identified.

4.3.2.3.2 The Role of Capital Resources in the Allocation of Spectrum

The view has often been expressed that a small, rich group would end up with all the spectrum rights if they were sold or leased. This is an empirical question; its validity can be determined only by trying it. There are, however, fairly compelling reasons for doubting its validity. If firms and individuals are motivated by self-interest and spectrum rights were transferable, a business entity would only retain spectrum rights as long as their value exceeded

the price it could get if it sold or sublet the rights. Those who could use the spectrum to better advantage would be willing to pay enough to induce the original owner of the right to transfer it to him. Although the rich tend to own more of most things, there is every reason to believe that anyone could get all the spectrum he wanted if he were willing to pay the going price.

One must acknowledge the possibility of a regulated natural monopoly acquiring, holding and using greater quantities of rights to use spectrum than was socially desirable. The incentive for firms in this category to sell rights to others who are willing to pay more than the value to the regulated monopoly is perhaps less strong since they operate on a cost base and are more or less assured of a stipulated return in capital. In any event, if there were great concern over the possibility of undesirable concentration of ownership occurring, limits in the amount of spectrum any one group or person could control could be devised.

It has also been suggested that those with large financial resources could make substantial profits speculating in spectrum rights. We see no particular reason why the rate of return from trading in spectrum rights would be systematically different from speculation in land or common stocks. The price of spectrum rights could be expected to move up and down with technological changes and other factors affecting supply and demand conditions.

4.3.2.4 Problems in Using the Price Mechanism to Allocate Spectrum

To work smoothly and efficiently, the price mechanism requires that property rights be defined, i.e. the nature of the package of rights to be sold or leased should be clear. A fundamental premise of the price mechanism is that the owner of a resource can exclude others from its use. If he cannot, the incentive to owning it is reduced and the efficiency of the price mechanism declines.

Ideally, the definition of property rights should be:

(a) Unambiguous

(b) Exclusive

(c) Transferable

(d) Enforceable

To the extent these conditions and the others discussed earlier in Section 4.3.2.2 are met, the price mechanism offers great potential as a device for allocating scarce resources in a efficient way.

If the rights to use spectrum are to be sold or leased, it will be necessary to create packages of rights. This might include such things as, (a) length of time for which the purchaser has the use of the right, (b) the hours of the day in which he is permitted to use the spectrum space, (c) the quality of the service he is buying, i.e. the degree of interference if any, and, (d) the geographic area within which he must confine his signals. Items (c) and (d)

pose difficult but not insurmountable problems. The nature of the problem can best be seen against the back-drop of our four desirable characteristics of property rights.

(a) Rights should be unambiguous:

The stipulation of unambiguous property rights in spectrum is complicated by the general nature of propagation of electromagnetic signals. Although it may be convenient to assume that signal radiation will cover a circle of a known size, (given power, frequency, antenna characteristics etc.) this is, at best, a rough approximation to reality. The size and shape of the area covered will vary substantially with such exogeneous factors as precipitation, sun spots, height of newly constructed buildings in the area, as well as other random factors. Accordingly, it is difficult to define in a precise way some important aspects of the right that is being sold or leased. The definition of property rights for spectrum is essentially probabilistic in nature. One cannot speak of the area covered but rather of its expected value and variance. The situation is roughly analogous to selling cars where the buyer is told that there are approximately 8 chances in ten that he will have the car for his exclusive use 300 randomly chosen days per year. It is important to note, however, that complete 100% control or ownership of an asset is not a necessary condition for the price mechanism to operate more effectively than alternative schemes. The price mechanism allocates land over which the owner lacks complete control

(it may be re-zoned, a new building may alter the view, he may not grow tobacco on it, etc.).

History suggest that the courts can sort out property rights in ways that work. The problems of the ownership of the right to use water for example has complexities of a similar nature to those faced in the definition of rights for spectrum usage. New problems present themselves to the courts from time to time, e.g. ownership of the air rights above a piece of land. These problems are solved; it seems reasonable to suppose that the problems peculiar to spectrum could also be solved.

(b) Exclusivity

The price mechanism works well when others can be excluded from using the resource in question. Ideally, rights should be exclusive. Under the price mechanism, a user of spectrum space might bid on and receive the right to cover an area 50 miles in radius centred in, say, Winnipeg. Generally it might be expected that an adjacent assignment (package of rights) will cover part of his territory some of the time and cause a degree of interference. Thus his right is exclusive only in a probabilistic sense. Of course, the package of rights to be sold or leased could be devised to reduce the probability of interference to as near zero as desired.

(c) Transferability

It is essential that rights be transferable if the market mechanism is to

function effectively. Without this feature, there is no reason to believe that the highest valued uses will be satisfied.

(d) Enforceable

Rights must be enforeeable. The incentive to own or rent spectrum rights is reduced to the extent that rights are unenforceable. Again the courts would have a role to play in the definition of property rights.

The establishment of appropriate property rights would entail some cost to society. Against these costs must be weighed the benefits derived from improved resource allocation.

It is trite to observe that the spectrum is a non-depletable resource. For this reason, experimentation with various techniques for managing the resource is made attractive. If mistakes are made, the power of eminent domain would presumably be available to rectify errors.

4.3.2.5 Conclusions

Given the foregoing, the market mechanism appears to be a valid alternative for dealing with a condition of excess demand for spectrum. The cost incurred in employing this solution are the economic benefits foregone by those users who are denied spectrum, (i.e.) the sum of their economic value for spectrum less the sum of the economic benefits they receive from the next best system of communication.

4.4. The Relative Value Concept: How to Use Economic Value to Exclude Users

The previous sections of Chapter 4 have been concerned with defining the concept of the value of spectrum usage and exploring alternatives which may allow us to measure such an economic value. We must finally consider:

(1) how economic value could be used to exclude users in a situation of excess demand for spectrum;

(2) which alternative methods of measuring economic value is best;

(3) what are the economic considerations of its use as a solution to excess demand; and,

(4) when would it be best to use this method (alternative C; excluding users on the basis of economic value for spectrum usage) for dealing with the problem of excess demand for spectrum space.

4.4.1 The Criterion of Exclusion

Remembering that spectrum assignment for essential services are now justified on essentially non-economic grounds, and assuming exclusion is politically acceptable; the following applies only to non-essential users.[1]

Assuming we have successfully determined the economic value for all users by one of the first two alternative methods (body of experts, or experimental simulation) these values would automatically rank all users as to their relative value for spectrum usage. The values would be stated on some unit of measurement such

---

1. If you agree with the logic of section 4.3.2.3.1.1.2. then the discussion would apply equally well to essential services.

as dollars/voice channel/year. Using the ranking as a guide, the spectrum manager would assign frequencies to users with the highest values until no more frequencies were available.

For the case of increasing licence fees, the users' own values would decide the exclusion, and for the market mechanism we would simply define the property rights of spectrum and let the users sort out among themselves who has the greater value for its usage.

Thus the relative values of users for spectrum usage whether managed by the DOC or by a market mechanism would determine the allocation, and automatically exclude those users with the lower economic values. If done by the D.O.C. with either experts or experimental simulation, a relative value scale (index) would be the guide.

Those who wish to consider social values would have to readjust the relative value scale or weight it in some way to reflect their values about non-economic factors.

4.4.2 Which Method of Measuring Economic Value is Best?

No simple answer presents itself for this question. We can suggest, however, that experimental simulation is better than the body of experts approach because it measures the users' judgments about the value of spectrum and not how others think he should value it. Unfortunately the simulation technique is not perfected and there is a chance that it can't be made to work. In general, however, we think there is a good chance it can be developed by a good team of psychologists.

Raising license fees, however, is far superior to both because it permits the user in a real life situation to decide how valuable spectrum is to him.

In deciding between raising the license fees and the market mechanism no conclusion is obvious. If, however, a market mechanism is politically unacceptable or definition of property rights is too difficult, then raising the license fee is the best choice.

4.4.3 Economic Considerations of Exclusion as a Solution to Excess Demand

Whether exclusion of users is achieved by a body of experts, experimental simulation or a market mechanism we must ask what the economic costs will be. The users denied spectrum space would have some value for it but, unfortunately, less value than other users who received assignments. The total of the economic values for spectrum usage, which would have been received by users denied space, minus the economic benefit they receive fromtheir next best alternative communication system, is the economic cost of this solution to the problem of excess demand.[1] This total is the foregone benefits which the users and the economy do not receive. In other words, the exclusion solution prevents those users denied space the incremental effect on income they would receive from spectrum usage and the economy therefore, does not receive these effects either.

4.4.4 When is Exclusion the Best Solution to the Situation of Excess Demand?

Excluding users from spectrum usage on the basis of their economic value for spectrum usage is one of four alternatives for dealing with excess demand.[2]

---

1. The economic benefit received from the next best alternative system of communcation is a contribution to G.N.P.
2. See part 1 Section 1.2.2.1

To refresh the reader's memory these were:

A. Band Reallocation;

B. Apply Technology;

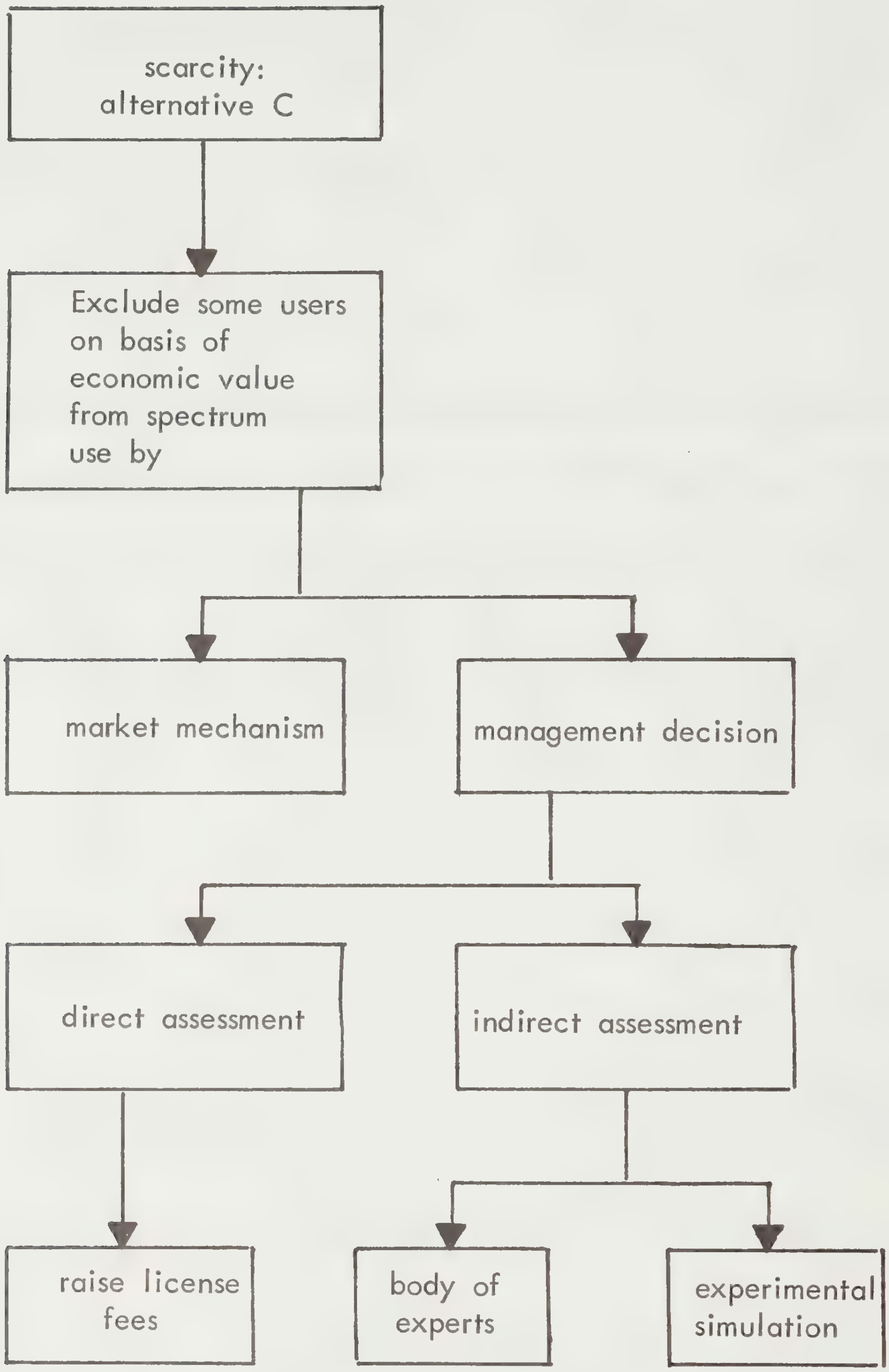
C. Exclude Users on the Basic of Economic Value of Spectrum Usage; and,

D. Lower the Quality: Allow More Interference.

Any one or a combination of them can be used to deal with excess demand. Exclusion (C) is the better solution when the costs of employing it (total of foregone benefits) are less than the costs of any of the other alternatives (A, B, and D).

A Flow Chart and Decision-Tree applicable to this alternative for dealing with excess demand are found on the following two pages.

EXCLUSION


scarcity:
alternative C
Exclude some users on basis of economic value from spectrum use by
market mechanism
management decision
direct assessment
indirect assessment
raise license fees
body of experts
experimental simulation

Decision Tree - The Exclusion Solution

1. Criteria: Exclude users with lower economic benefits from spectrum use

↓

2. Measure Economic Value by

(a) Centralized Management Decision

a_1 Direct assessment: raise license fees

a_2 Indirect assessment

a_{2i} Body of experts

a_{2ii} Experimental simulation

(b) Market Mechanism

↓

3. Estimate the cost of each alternative above: foregone benefits minus value of alternative communication system.

↓

4. Choose alternative above with the lowest cost and compare with cost A, B, & D. If lower, implement.

CHAPTER 5

SUMMARY AND CONCLUSION

5.1 Introduction

The Terms of Reference of this study are broad and do not direct the authors to specific issues. The key phrases are "formulate a philosophy", "determine economic guidelines", "review", "consider", "explore", "study" and "identify cases". The foregoing discussion has endeavoured to fulfill these Terms of Reference by developing an integrated framework which identifies the available alternatives of Spectrum Management at all levels of analysis and for all conditions which may exist at any point in time and in any region or locality.

In the remainder of this chapter we discuss:

a) The basic philosophy for the incorporation of economic guidelines into the management of the radio spectrum;

b) procedures for implementation of the philosophy through the flow chart of spectrum management, and

c) a postscript.

5.2. A Philosophy for the Incorporation of Economic Guidelines into the the Management of the Radio Spectrum[1]

As the reader may well have noticed, a philosophy has implicitly been advocated throughout the discussions in this report. To approach an explicit statement of this philosophy we must first deal with the following.

> At any point in time, for all or any part of the spectrum, or region, or locality, assess the current situation. If there are no problems decide if encouragement is desirable and if so, how and to what degree. If a problem (scarcity) exists the philosophy can be stated as follows.

---

1. Term of Reference (a) on Page iii.

> Identify all possible alternatives for dealing with the problem and calculate or estimate the economic costs which would be incurred in their implementation; compare these economic costs and implement that alternative (or combination of alternatives) which achieves the minimum cost (entropy caused loss).

This philosophy encompasses only economic costs as it is beyond our terms of reference to deal with social costs. We readily admit that social costs should be considered and hopefully integrated with economic costs to form a joint guide for spectrum management [1].

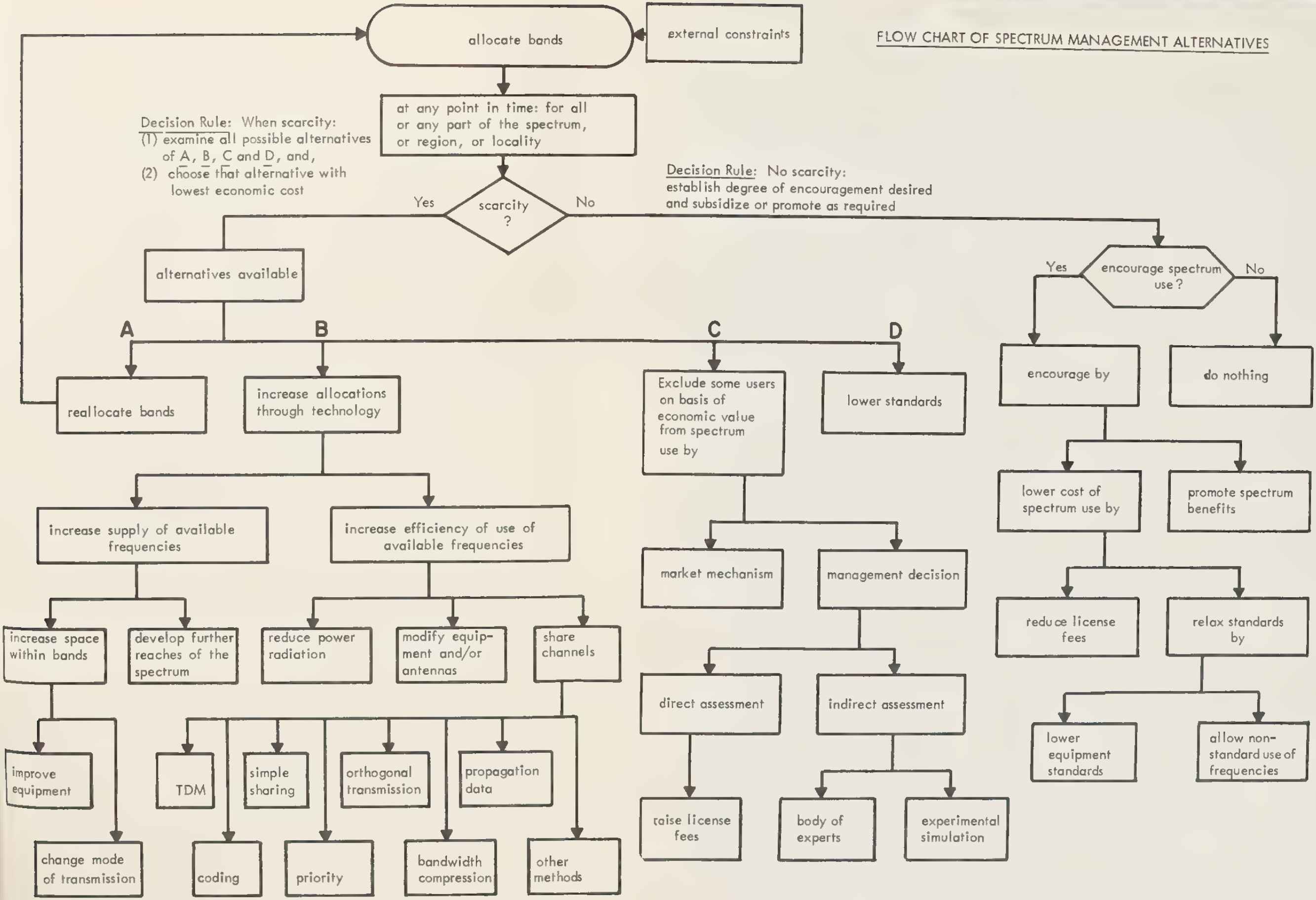
5.3 Procedures for Implementation of the Philosophy through the Flow Chart of Spectrum Management

We have attempted to identify all possible conditions and alternatives which may exist for spectrum management. No doubt, some alternatives may have been missed and in the future more may be developed, especially in the technical area. We would be pleased to incorporate any other valid alternatives which can be suggested.

In order to bring all the preceding discussions into a meaningful whole, a comprehensive Flow Chart of Spectrum Management, incorporating all the alternatives and the relationships between them, is given on the following page. The basic management decision rules are included on the flow chart. This is followed by detailed decision trees for each major condition.

---

1. The level at which they should be considered is the central issue. It is our judgment that social benefits (externalities) should be considered in determining what services should be offered and in what quality. The provision of factor inputs (e.g. spectrum) is probably best left to the market mechanism.


allocate bands
external constraints
at any point in time: for all or any part of the spectrum, or region, or locality
Decision Rule: When scarcity: (1) examine all possible alternatives of A, B, C and D, and, (2) choose that alternative with lowest economic cost
scarcity ?
Yes
No
Decision Rule: No scarcity: establish degree of encouragement desired and subsidize or promote as required
alternatives available
A
B
C
D
reallocate bands
increase allocations through technology
Exclude some users on basis of economic value from spectrum use by
lower standards
encourage spectrum use ?
Yes
No
encourage by
do nothing
increase supply of available frequencies
increase efficiency of use of available frequencies
market mechanism
management decision
lower cost of spectrum use by
promote spectrum benefits
increase space within bands
develop further reaches of the spectrum
reduce power radiation
modify equipment and/or antennas
share channels
direct assessment
indirect assessment
reduce license fees
relax standards by
improve equipment
change mode of transmission
TDM
coding
simple sharing
priority
orthogonal transmission
bandwidth compression
propagation data
other methods
raise license fees
body of experts
experimental simulation
lower equipment standards
allow non-standard use of frequencies

The Decision Trees for each major condition (scarcity-no scarcity) and each major alternative to scarcity (_A_, _B_, _C_, & _D_) are found on the following pages.

DECISION TREE - NO SCARCITY

1. Decide whether spectrum use will be encouraged.

↓

2. If yes: decide to what degree and by what method as shown on Flow Chart.

↓

3. Implement your best social and political choice.

Alternative A

Decision-Tree - Band Reallocation

1. Inputs

   (a) Determine the current state of spectrum utilization for all bands by type of use, in all regions and localities.

   (b) On the basis of the best information available, predict the technological advances which are, or will become available to increase the supply of usable spectrum.

   (c) On the basis of the best information available, predict the future demand for spectrum space by type of use for all regions and localities.

↓

2. On the basis of (a), (b) and (c) above, develop a reassignment of bands which achieves the best fit with current and expected events and also preserves the highest possible degree of flexibility should events turn out differently than expected.

↓

3. Determine the costs that will be incurred: (1) through any adjustments in equipment, required of users, to meet the requirements of the new plan; (2) for research and development required to implement the plan; and, (3) for the Department of Communications to administer the implementation of the plan.

↓

4. If the costs of reallocation are less than alternatives B, C and D choose reallocation as the solution to excess demand.

↓

5. If A is the least expensive alternative, devise a scheme for apportioning the costs of the reallocation.

Alternative B

Decision Tree - Extend Space and Use Through Technology

1. Alternatives
   - (a) Increase Supply of Available Frequencies
     - a_1 Develop further reaches of the spectrum
     - a_2 Increase space within bands
       - a_{2i} improve equipment
       - a_{2ii} change mode of transmission
   - (b) Increase Efficiency of Bandwidth Use
     - b_1 Reduce power requirements
     - b_2 Modify equipment and/or antennas
     - b_3 Share channels (following methods or others)
       - b_{3i} TDM
       - b_{3ii} coding
       - b_{3iii} simple sharing
       - b_{3iv} priority sharing
       - b_{3v} orthogonal transmission
       - b_{3vi} bandwidth compression
       - b_{3vii} propagation data

↓

2. Estimate cost of each alternative:
   R & D, plus user capital cost, plus D.O.C. costs (management).

↓

3. Compare the costs of each alternative to identify the least costly.

↓

4. Compare identified lowest cost alternative with the costs of alternatives A, C and D. If lower, implement.

Alternative C

Decision Tree - The Exclusion Solution

1. Criteria: Exclude users with lower economic benefits from spectrum use

↓

2. Measure Economic Value by

   (a) Centralized Management Decision
   - a_1 Direct assessment: raise license fees
   - a_2 Indirect assessment
     - a_{2i} Body of experts
     - a_{2ii} Experimental simulation

   (b) Market Mechanism

↓

3. Estimate the cost of each alternative above: foregone benefits minus value of alternative communication system.

↓

4. Choose alternative above with the lowest cost and compare with cost A, B, & D. If lower, implement.

Alternative D

DECISION TREE - LOWERING QUALITY: ALLOW MORE INTERFERENCE

1. Estimate the costs of employing this solution: The difference between Type I and Type II losses.

↓

2. Compare cost with alternatives A, B and C and if lower, implement.

We are strongly convinced that the philosophy, the Flow Chart of Spectrum Management, and the decision trees presented on the previous pages can achieve the best possible minimization of entropy in spectrum management.

Since many of the inputs cannot be accurately measured and the future is not accurately predictable it is probable that entropy effects cannot be avoided entirely. It is only possible in this situation to strive for the best possible minimization of entropy effects in the management of the radio spectrum.

5.4. Postscript

It is possible that most of the inputs specified in the decision trees are currently being gathered by other study groups of the Telecommission. For example, the terms of reference of Telecommission Study 2 (h) indicates that it should be providing much of the information required in the decision trees for band reallocation and the application of technology.

If, however, not all information required by the decision procedures is being gathered and gaps occur, the approach of this report, although still useful, cannot be completely employed to its logical end.

APPENDIX A

The Fallacy of Using the Cost (price) of Spectrum as Measure of the Economic Value of Spectrum Use.

We must state categorically that measurements of costs: (1) of radio communications systems; and/or (2) of alternative communication systems cannot be used to measure the economic value of spectrum use. We include this section, however, since much of the literature[1] on the value of spectrum usage attempts to use a "measurement of costs" approach, and for a time these authors were led down this same garden path.

It is very simple to debunk the concept of measuring the economic value of spectrum use by measuring the costs of spectrum or costs of alternative communication systems. We have shown in Section 4.2.3 that the real value of spectrum usage is the incremental effect of its usage on the revenue statements (gross revenue) of the user[2]. On this point the literature is fairly well in agreement[3]. The following logic demonstrates that the costs associated with spectrum usage, or any communication system for that matter, are not related to the value of spectrum.

> A spectrum user receives an incremental effect on gross income from spectrum usage. The price he pays (cost) for spectrum usage may be less than, equal to, but not greater than the income effect. If it is greater the user is economically rational to not use spectrum.
>
> The user would be economically rational to pay any price (cost) for spectrum usage up to that point where the price (cost) is just equal to the income it generates.

---

1. For example see Hoxie, L.E., "The Relative Value Index Concept of Spectrum Management", Prepared for the Office of Telecommunications Management, U.S.A., pp. 13-32.
2. This is also its effect upon the GNP of the Country.
3. Hoxie, L.E., op. cit., p. 25.

> The income generated is not dependent upon the price paid for its use. Except in the rare, knife-edged case, where the price (cost) of spectrum facing a user is equal to the value of the spectrum, the price (cost) the user pays will be smaller (often very much smaller) than its value. The difference is the familiar concept of "Consumer Surplus".[1] If we know the dollar value of this consumer surplus then the total of his surplus and his costs (price of spectrum) will be equal to his economic value for spectrum usage.

The measurement of consumer surplus is probably more difficult than measuring the income effect, therefore it is a better choice to try and find a direct measure of spectrum income effects.

In conclusion, any attempt to measure the value of spectrum usage through the measurement of costs is fallacious.

---

1. Readers unacquainted with the concept of Consumer Surplus would be well advised to refer to the literature of economics on this point.

MAJOR SOURCES CONSULTED

A. BOOKS AND MONOGRAPHS

Borchardt, Kurt, Structure and Performance of the U.S. Communications Industry, Harvard University Press, Boston 1970.

Dorfman, Robert (ed.), Measuring Benefits of Government Investments, The Brookings Institution, Washington D.C., 1965.

Mathison, Stuart L. and Walker, Philip M., Computers and Telecommunications: Issues in Public Policy, Prentice Hall, Englewood Cliffs, N.J., 1970.

Rostow, Eugene V., Final Report: Presidents' Task Force on Communications Policy, Washington D.C., 1968.

B. JOURNAL ARTICLES

Coase, R. H., "The Federal Communications Commission", Journal of Law and Economics, (University of Chicago), October 1959, pp. 1-40.

Coase, R. H., "The Interdepartment Radio Advisory Committee", Journal of Law and Economics, Vol. 5, October 1962, pp. 17-47.

Coase, R. H., "The Economics of Broadcasting and Advertising", American Economic Review, Vol LVI, (May 1966), No. 2, pp. 440-466.

Herzel, L., "Public Interest and the market in Colour Television Regulation", University of Chicago Law Review, XVIII (1951), p. 802.

Levin, H. J., "Federal Control of Entry in the Broadcast Industry", Journal of Law and Economics, Vol. 5, October 1962, pp. 49-67.

Musgrave, Richard A., "Cost Benefit Analysis and the Theory of Public Finance". Journal of Economic Literature, Vol. VII. No. 3, pp. 797-806.

Prest, A. R., and Turvey, R., "Cost Benefit Analysis: A Survey", The Economic Journal, Vol. LXXV., December 1965, pp. 683-735.

Smythe, Dallas W., "Facing Facts about the Broadcast Business", University of Chicago Law Review, Vol. XX., (1952), p. 96.

C. TECHNICAL REFERENCES

Drury, Hon. C. M., A Domestic Satellite Communication System for Canada, White Paper, Minister of Industry, March 1968.

Joint Technical Advisory Committee, Spectrum Engineering - The Key to Progress, IEEE, New York, 1968.

Official Transcript, 18th Annual National Cable Television Association Convention, June 22-25, 1969.

Rostow, E. V., Final Report, President's Task Force on Communications Policy, U.S. Government Printing Office, December 1968.

The Broadcasting Act, March 7, 1968.

The Telesat Canada Act, June 29, 1969.

FCC Docket No. 18802, February 19, 1970.

All issues of the following list of periodicals as of January 1968 until June 1970.

Canadian Electronics Engineering, MacLean-Hunter, Toronto.

E.E.E., Mactier Publishing Corp., Minnesota.

Electronics Design, Hayden Publishing, New York.

Electronics, McGraw-Hill, New York.

I.E.E.E. Spectrum, New York.

Proc. I.E.E.E., New York.

Telecommunications, Horizon House, Dedham, Massachusetts.

C. BRIEFS AND WRITTEN COMMENTS RECEIVED

Trans Canada Telephone System, "Proposed Outline of the Study", (November 26, 1969).

Canadian Electrical Association, "Comments on Interim Report", (May 28, 1970).

C. Hughes, DOC, "Comments on Interim Report", (March 25, 1970).

Canadian Radio Technical Planning Board, "Comments on Interim Report", (May 6, 1970).

Canadian Broadcasting Corporation, "Comments on Interim Report", (April 28, 1970).

E. King, DOC, "Comments on Interim Report", (April 22, 1970).

"The Economic Aspects of Radio Frequency Spectrum Management", (November, 1969).

Association of Municipal Electrical Utilities of Ontario, (October 22, 1969).

Canadian Association of Broadcasters, (March 9, 1970).

Air Services, Department of Transport (November 18, 1969).

Ontario Department of Education, (October 21, 1969).

TMC (Canada) Ltd., (October 22, 1969).

Telephone Association of Canada, (October 31, 1969).

Amateur Users, (undated).

CAB, (October 24, 1969).

RCA, (October 24, 1969).

Tupper Telecommunications Consultant, (October 23, 1969).

Trans Canada Telephone System "Frequency Spectrum Management", (March 4, 1970).

Restricted Common Carrier Mobile Radio Service, (October 30, 1969).

Air-Tel Corporation, (June 30, 1970).

CN (November 3, 1969).

CP (October 30, 1969).

D. GROUPS AND INDIVIDUALS CONSULTED

Task Force 4 of Study Group 2(h), Ottawa, (April 22, 1970).

Director of Research, (Dr. W. V. Tilston), Sinclair Radio Laboratories, Toronto, (June 16, 1970).

Electronics Industry Association (at Motorola), Suppliers, Toronto, (February 26, 1970).

Electronics Industry Association, Toronto, (June 16, 1970).

Canadian Electrical Association, Toronto, (June 16, 1970).

Canadian Radio Technical Planning Board, Ottawa, (May 14, 1970).

Trans Canada Telephone System, Toronto, (December 16, 1969).

Trans Canada Telephone System, Toronto, (March 20, 1970).

Hamilton Fire Department, L. G. Saltmarsh, Department Chief.

Staff of the Department of Communications.

Burton Ford (user).

Wentworth Taxi Ltd. (user).

Police Department (Hamilton).

C. E. Webster, Chief Engineer, CN-CP Communications (June 23, 1970).

Raymond Spence, Chief, Federal Communications Commission Task Force and His Team, (June 26, 1970).

Canadian Association of Broadcasters, Hamilton, (March 6, 1970).